Ethan Allen
Naval Architecture
Factual Report

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PASSENGER VESSEL ETHAN ALLEN
STABILITY ANALYSIS

PRELIMINARY REPORT
DELIVERABLE 1: TASKS 1-5

prepared for:

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TABLE OF CONTENTS

EXECUTIVE SUMMARY ---- 1
VESSEL PARTICULARS ---- 3
TASK 1 ---- 4
Assumptions ---- 5
Description of Computer Model ---- 5
TASK 2 ---- 5
Overview ---- 5
Calculations ---- 7
TASK 3 ---- 8
TASK 4 ---- 9
Applicable Standards ---- 9
Results ---- 10
TASK 5 ---- 12
Applicable Standards ---- 12
Results ---- 13

APPENDICES

HECSALV COMPUTER MODEL ---- APPENDIX A
LIGHTSHIP CALCULATION ---- APPENDIX B
SIMPLIFIED STABILITY CALCULATION ---- APPENDIX C
SUBCHAPTER S STABILITY CALCULATIONS ---- APPENDIX D

REFERENCES

1. 46 CFR Subchapter T – Small Passenger Vessels (Under 100 Gross Tons), Part 178, Subpart C – Intact Stability Standards, 2002.
2. Scarano Boatbuilding Inc., Inclining Report, 29 October 2005.
3. 46 CFR 178.330 Simplified Stability Proof Test, 2002.
4. 46 CFR Subchapter S – Subdivision and Stability, Subpart E – Weather Criteria, 170.170 Calculations Required, 2002.
5. 46 CFR Subchapter S – Subdivision and Stability, Subpart E – Weather Criteria, 170.173 Criterion for Vessels of Unusual Proportion and Form, 2002.
6. 46 CFR Subchapter S – Subdivision and Stability, Part 171 – Special Rules Pertaining to Vessels Carrying Passengers, 171.050 Intact Stability Requirements for a Mechanically Propelled or a Nonself-Propelled Vessel, 2002.
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EXECUTIVE SUMMARY

At the request of NTSB, JMS has performed intact stability calculations for the passenger vessel ETHAN ALLEN. ETHAN ALLEN is a Dyer 40 fiberglass mono-hull design built in 1964 by the Anchorage in Warren, Rhode Island. The Dyer 40 has been in production since 1960 in a variety of configurations including launches similar to the ETHAN ALLEN.

On October 2, 2005 the NY state certified vessel Ethan Allen was touring Lake George with 47 passengers and one NY State licensed crewmember on board. The vessel proceeded northbound and approached an area on the lake called Cramer Point when the master began a turn to starboard. According to most of the passengers, the vessel heeled to port and capsized. After remaining inverted on the surface for a short period, the vessel subsequently sank. The master and 27 passengers survived. Twenty passengers died.

The ETHAN ALLEN was initially certificated by USCG to carry 48 passengers as a USCG 46 CFR Subchapter T vessel (Reference 1). During her 41 years of operation, the ETHAN ALLEN was modified several times with protective canopies over the passenger area. At the time of the accident a wooden canopy with retractable Plexiglas side windows covered the passenger area. The vessel had also been repowered with a single 110 horsepower diesel engine.

This report summarizes the findings of the first five tasks of NTSB's Statement of Work. These tasks are as follows:

1. Develop an accurate computer model of the vessel hull form
2. Calculate the lightship weight and center of ETHAN ALLEN, at the time of the accident, based on the inclining experiment conducted on sister vessel deCHAMPLAIN (Reference 2).
3. Calculate the lightship weight and center of ETHAN ALLEN for several previous conditions of the vessel: as delivered by the builder, and with multiple designs of canvas canopy.
4. Based on the lightship weights and centers found in Tasks 2 and 3, determine the maximum passenger loading that will meet USCG simplified stability criteria in 46 CFR 178.330 (Reference 3).
5. Based on the lightship weights and centers found in Tasks 2 and 3, determine the maximum passenger loading that will meet USCG stability criteria in 46 CFR Subchapter S: 46 CFR 170.170 Wind Heeling Moment (Reference 4), 46 CFR 170.173 Vessels of Unusual Form (Reference 5), 46 CFR 171.050 Passenger Heeling Moment (Reference 6).

In order to develop the hull form for the vessel, a laser survey was completed by 3D Measure Inc. of Newport, Rhode Island. This survey yielded a three dimensional computer model that could be imported into HECSALV stability software for the analysis.

The lightship weight and longitudinal center of gravity of ETHAN ALLEN at the time of the accident was estimated based on the weight measured on a truck scale, along with freeboard measurements of the vessel afloat (Reference 7). The vertical center was calculated based on the inclining test performed on the sister vessel, deCHAMPLAIN, (Reference 2). The hydrostatic properties based on Task 1 were used for both vessels. The resulting weight and center are given in Table 1.

Table 1. ETHAN ALLEN 2005 Lightship Condition

Lightship Weight	14,689 lbs
VCG	5.29 feet above BL
LCG	19.5 feet aft FP

Figure 1 shows a flow chart of the various vessel configurations and calculations in Tasks 3 through 5. These include multiple canopy designs as well as calculations in salt and fresh water. This represents the vessel's previous operation on the Thames River, Connecticut and recent operation on Lake George. For the simplified stability test, a center of gravity of the test weights is specified as 2.5 feet above the deck. At the request of NTSB, a center of gravity of 1.5 feet above the deck is also examined for the as delivered case.

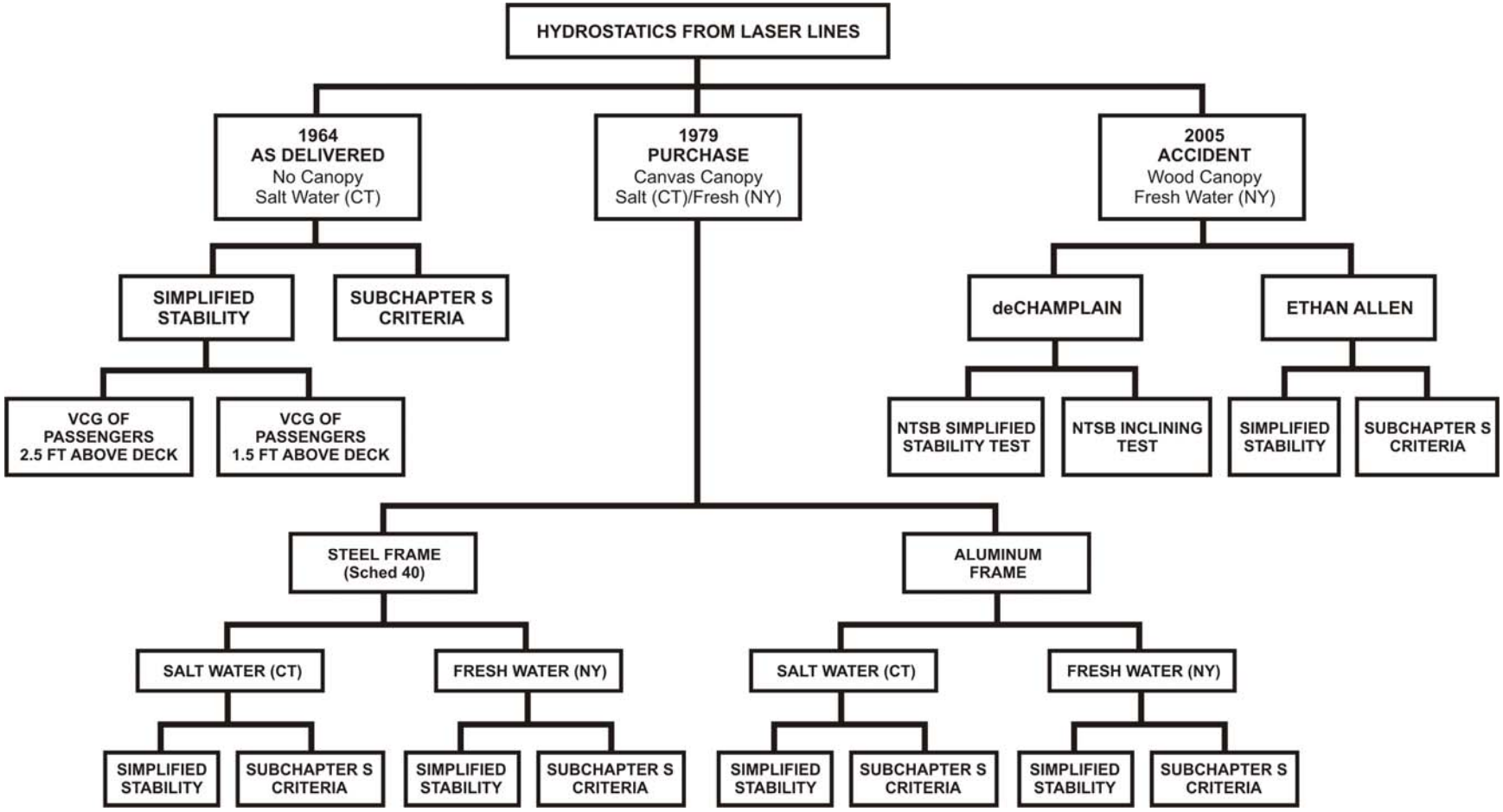

Figure 1. Flow Chart of Stability Calculations

Scarano Boatbuilding's report, Reference 8, presents several canopy designs. Three of these are considered in this analysis – canvas canopy with schedule 40 steel frame, canvas canopy with schedule 40 aluminum frame, and final wooden canopy. The vessel reportedly had no canopy when originally delivered. Lightship weights and centers of the five vessel configurations are shown in Table 2. deCHAMPLAIN is included as a benchmark, using the results of the inclining experiment,. Reference 2.

Table 2. Lightship Conditions of Alternate Vessel Configurations

	1964	Steel Canopy	Al Canopy	deCHAMPLAIN	2005
Weight	12,759 lbs	14,590 lbs	13,542 lbs	14,315 lbs	14,689 lbs
VCG	4.5 feet abv BL	5.4 feet abv BL	4.9 feet abv BL	5.4 feet abv BL	5.3 feet abv BL
LCG	19.4 feet aft FP	19.5 feet aft FP	19.4 feet aft FP	19.8 feet aft FP	19.5 feet aft FP

Only the vessel design with no canopy can pass the simplified stability test, regardless of the number of passengers. This is because with the canopy installed, the wind heeling moment is governing over the passenger heeling moment. The marginal stability was also borne out in the test that was performed on the deCHAMPLAIN by NTSB on 5 October 2005. (Reference 9). During that test, approximately half of the required heeling moment was imposed before the test was halted when the vessel was close to the minimum freeboard. Table 3 shows the results of Task 4 – maximum passenger loading for simplified stability criterion. Passenger counts are based on 140 pounds per person, the USCG standard for protected waters.

Table 3. Maximum Passenger Loading for Simplified Stability Test

Condition	Total Passenger Weight	Passengers (140 lb/pax)
1964 – VCG 2.5 ft abv deck	5,740 lb	41
1964 – VCG 1.5 ft abv deck	6,580 lb	47

Table 4 shows the results of Task 5 – maximum passenger loading for Subchapter S criteria. Passenger counts are based on 140 pounds per person, the USCG standard for protected waters. As in the simplified criteria, canopy conditions do not meet the wind heel criteria regardless of passenger count. The wood canopy does meet the criteria with a reduced number of passengers. This is because the wood canopy is lower than the canvas.

Table 4. Maximum Passenger Loading for Subchapter S Stability Criteria

	170.170 Wind Heel		170.173 Unusual Form		171.050 Passenger Heel	
Condition	**Total Passenger Weight**	**Passengers (140 lb/pax)**	**Total Passenger Weight**	**Passengers (140 lb/pax)**	**Total Passenger Weight**	**Passengers (140 lb/pax)**
1964 – as delivered	>21,000	>150	8,260	59	8,120	58
1979 – Steel Canopy – SW	FAIL		1,540	11	6,860	49
1979 – Steel Canopy – FW	FAIL		1,400	10	6,720	48
1979 – Al Canopy – SW	FAIL		5,180	37	7,560	54
1979 – Al Canopy – FW	FAIL		5,040	36	7,560	54
2005 – Wood Canopy	2,940	21	1,960	14	6,860	49

VESSEL PARTICULARS

Owner: Shoreline Cruises, Lake George, NY
Built: 1964 – The Anchorage, Warren, RI
Model: Dyer 40
Hull No.: 7

Length Overall:	39.5	ft
Length Between Perpendiculars	33.5	ft
Beam:	12.4	ft (molded, MS)
Depth:	5.93	ft (molded, MS)

TASK 1

3D Measure Incorporated was contracted by JMS Naval Architects to measure and produce an as-built offset file of the ETHAN ALLEN.

The following persons were present during the measurement: Robert W. Henry, Naval Architect, and Barry Strauch, Ph.D. from the National Transportation Safety Board, Washington, DC, T. Blake Powell, and Rick Fernandes from JMS Naval Architects & Salvage Engineers, Groton, CT.

The measurement was done on the ETHAN ALLEN on February 16, 2006 in Lake George, New York. The vessel was firmly supported by jack stands and wooden blocks under the keel.

Laser measurement points were taken using a Nikon NPL 820 Digital Pulse Laser Total Station. The instrument was checked for accuracy several times during the measurement and the accuracy was found to be within 2mm. Data points were collected on the port side, starboard side, bow and transom of the vessel. A total of 645 data points were collected. Measured points were then imported from the Nikon Total Station onto a laptop using Nikon Transit software version 2.31. Points were then imported into MultiSurf, a Computer Added Design (CAD) software program. Collected data points were reviewed by representatives of NTSB and JMS.

The data was used to produce a wire frame and a surface model. The surfaces were then checked against the original data points. Most of the points were less than 1.5mm from the surface. The surface model was vertically sliced into 46 stations defining the hull for the HECSALV hydrostatic program. Figure 2 shows the surface hull model in Rhinoceros. Figure 3 shows the wire frame station model in HECSALV.

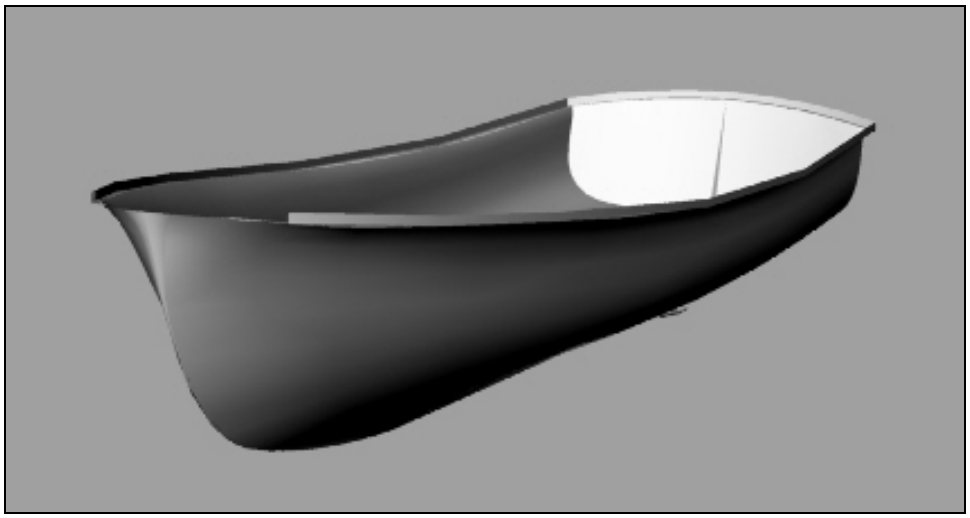

Figure 2. 3D Model of Ethan Allen Hull

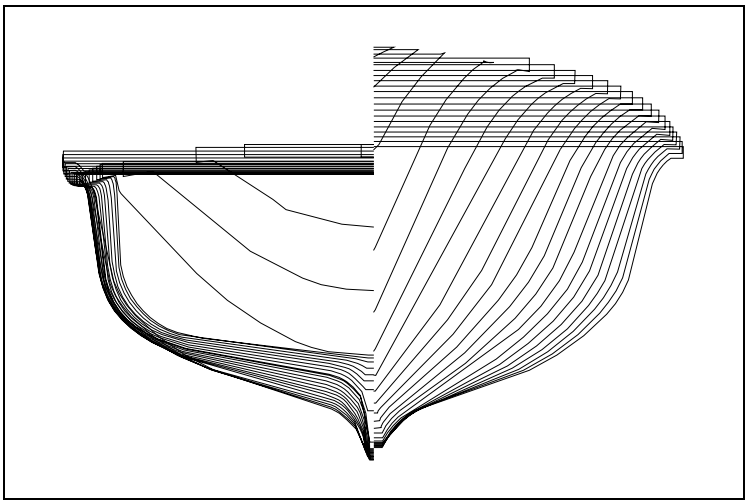

Figure 3. Hydrostatic Model of Ethan Allen Hull

Assumptions

Several key assumptions affect interpretation of the hull model and analysis.

1. The baseline of the vessel is assumed to be at the bottom of the vessel at midships. This differs from the previous model and lines plans, which had the baseline 6.5 inches below the bottom of the vessel.
2. The length between perpendiculars is measured from the rudder stock to the intersection of the stem with the 2.47 foot reference waterline.
3. Passenger weight distribution is based on a uniform weight of passengers seated in the 2005 bench arrangement. This is slightly asymmetrical due to the arrangement of three-seater benches on the port side and two-seaters on the starboard side (Reference 10).
4. Offsets were measured to the outside of the hull. Therefore, there is no allowance for the sideshell. Because the displacement of the rudder and propeller are small, they are ignored in this analysis.

Description of Computer Model

A computer model of the vessel was created using Herbert Engineering Corporation's hydrostatic software package, HECSALV Version 7.6.6. This model includes hull offsets and hydrostatic properties, compartments and subdivision, and weights and centers. All information necessary for intact or damaged stability calculations is present.

Two models were used for this analysis. The first abbreviated model contained only the minimum required, allowing the displacement to be calculated from freeboard measurements. For the stability calculations, the model is constructed including compartments, weights, and centers, based on the 1964 vessel as delivered. For the alternative configurations, the canopy is included as a deadweight item.

Details of the HECSALV model are contained in Appendix A.

TASK 2

Overview

The lightship weight and center of gravity of the ETHAN ALLEN were calculated based on results of several tests conducted by NTSBon this vessel and sister vessel deCHAMPLAIN. These include weight of both vessels measured on NY State Police truck scale and freeboards taken at the same time (Reference 7), and inclining test on deCHAMPLAIN (Reference 2). The results of all tests were calculated using the hydrostatic model developed from the laser measurement. Detailed calculations are included in Appendix B.

Table 5 and Figure 4 show the results for all five lightship estimates. The accuracy of the NY State Police scale is 2 percent, per NTSB, and the total weight – including truck and trailer – was 33,000 lbs for each test. Two percent corresponds to plus or minus approximately 660 pounds. In the draft range of these measurements, parallel sinkage of the vessel is approximately 1,300 pounds per inch. Therefore, one half inch of freeboard is equivalent to plus or minus 650 pounds. There is approximately 250 pounds of known weight difference between deCHAMPLAIN and ETHAN ALLEN: 150 lbs canopy, 38 lbs engine, and 55 lbs ballast; in all cases, ETHAN ALLEN is the heavier vessel.

The calculated weights at the time of each test were adjusted for deadweight items that were on board the vessels. Both vessels had some fuel on board. In addition, ETHAN ALLEN had water in the bilges and various gear. There were a hatch cover and one window missing from the ETHAN ALLEN at the time of the test. In the case of the deCHAMPLAIN inclining test, the deadweight adjustment includes personnel and test equipment.

Table 5. Lightship Weight Estimate

Vessel	Source	Date	Weight (pounds)	Deadweight (pounds)	Lightship (pounds)	LS Draft (in @ LCF)
Ethan Allen	Freeboards	12-Oct	15,252	611	14,641	29.26
Ethan Allen	Scale	12-Oct	15,300	611	14,689	29.29
deChamplain	Freeboards	12-Oct	14,288	535	13,753	28.61
deChamplain	Scale	12-Oct	14,850	535	14,315	29.03
deChamplain	Inclining	5-Oct	15,857	2,272	13,585	28.47

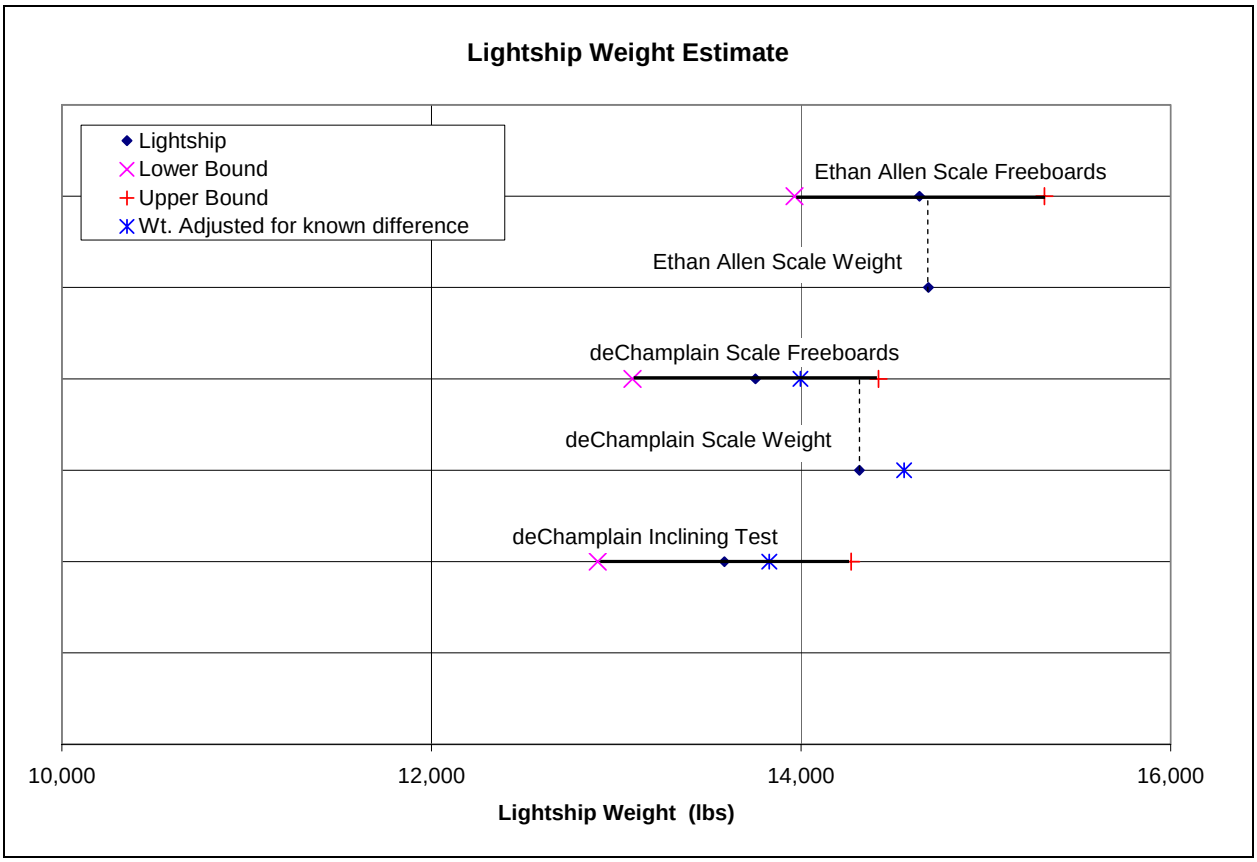

Figure 4. Lightship Weight Comparison

Because there is good agreement between the five weight estimates, the truck scale weight for the ETHAN ALLEN is used as the base weight in the stability calculations. The center of gravity was calculated from other data. The longitudinal center was derived from the freeboard measurements taken at the time of the scale test. The vertical center was adjusted from the deCHAMPLAIN inclining test.

Table 6. Lightship Weight and Centers
ETHAN ALLEN 2005

Weight	14,689 lb
VCG	5.3 ft aBL
LCG	19.5 ft aFP
Draft @ LCF	2.44 ft

Calculations

Freeboard measurements were taken at five positions along the hull for all of the tests. These five positions were in approximately the same location each time: bow, transom, and three intermediate points. Using the surveyed shear line and the measured freeboards, drafts were calculated for each test. Figure 4 shows an example of drafts over the length of the vessel. This plot is for the ETHAN ALLEN. Similar plots were constructed for the deCHAMPLAIN tests.

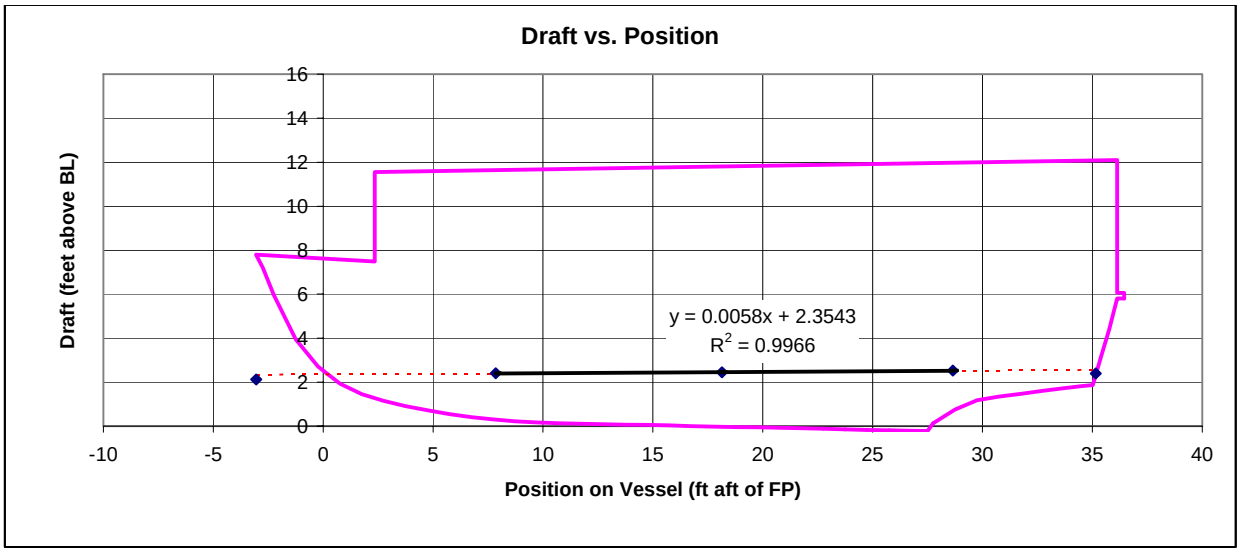

Figure 4. ETHAN ALLEN Drafts at Time of Truck Scale Weight Test

A straight line was fit through the center three points. This yields very good agreement (within 0.05 inches) with the center three points and agreement within 2.5 inches at the ends. This same process was used for the deCHAMPLAIN tests.

The weight and center derived from truck scale freeboards were adjusted for deadweight items that were on board the vessel at the time of the test, as shown in Table 7.

Table 7. Weights and LCG – Truck Scale Survey

	Weight	LCG
Test Weight	15,300 lb	19.3 ft aFP
Fuel	-178 lb	12.5 ft aFP
Water	-383 lb	14.6 ft aFP
Gear	-100 lb	13.0 ft aFP
To be added	50 lb	5.5 ft aFP
Lightship	14,689 lb	19.5 ft aFP

In order to determine the vertical center of gravity (VCG) of ETHAN ALLEN, data from the deCHAMPLAIN inclining test must be used. The known weight differences between ETHAN ALLEN and deCHAMPLAIN are in the engines, fixed ballast, and canopy; see Table 8. (Engine weights are taken from Reference 11.) Fixed ballast weights are based on the condition of the vessels at the time of survey as well as confirmation of unit weight of lead blocks (Reference 12). By adjusting for these known differences, the VCG of the hull portion of deCHAMPLAIN was calculated. Although the hull weight for deCHAMPLAIN and ETHAN ALLEN may not be exactly the same, due to minor construction or outfitting differences, it is assumed that the weight difference is evenly distributed over the hull and therefore the same VCG can be used for both vessels. The total lightweight VCG for ETHAN ALLEN is then built up by adding back the ballast, engine, and canopy, see Table 9.

Table 8. Weights and VCG – deCHAMPLAIN

	Weight	VCG
Lightship	13,585 lb	5.25 ft aBL
Engine	1,082 lb	3.00 ft aBL
Ballast	1,210 lb	1.75 ft aBL
Canopy	1,780 lb	10.8 ft aBL
Hull	9,513 lb	4.91 ft aBL

Table 9. Weights and VCG – ETHAN ALLEN

	Weight	VCG
Hull	10,484 lb	4.91 ft aBL
Engine	1,120 lb	3.00 ft aBL
Ballast	1,155 lb	1.75 ft aBL
Canopy	1,930 lb	10.8 ft aBL
Lightship	14,689 lb	5.29 ft aBL

TASK 3

The evaluation of multiple canopy variations is based on weight estimates from Scarano in Reference 8. Four different conditions were considered:

1. 1964 As Delivered, No canopy
2. 1979 Canvas canopy with schedule 40 steel frame (1831 lb)
3. 1979 Canvas canopy with schedule 40 aluminum frame (783 lb)
4. 2005 Time of accident, Wood canopy (1930 lb)

Weights from Reference 8 were confirmed based on the following assumptions:

- Height of the canvas canopy is 7'-11.44" above the deck at boarding threshold. This is scaled from photographs. Height of the wood canopy is 6'-8.25" above the deck at the boarding threshold, per Reference 8. This is confirmed by measurements taken by JMS.

- Longitudinal center of all canopies is taken to be 23 feet aft of the bow. This is in consideration of slightly more area in plan view aft.
- All canopies have the same arrangement of plexiglass windows. Total weight of windows is approximately 145 pounds based on 3/16" plexiglass on the existing canopy. The same value is used for the canvas canopy arrangements.

Table 10 summarizes the vessel lightship weight and center adjusted for each canopy configuration.

Table 10. Lightship Characteristics – Canopy Variations

	1. 1964	2. 1979	3. 1979	4. 2005
Canopy	None	Steel Frame	Al Frame	Wood
Lightship Weight	12,759 lb	14,590 lb	13,542 lb	14,689 lb
VCG	4.5 ft aBL	5.4 ft aBL	4.9 ft aBL	5.3 ft aBL
LCG	19.4 ft aFP	19.5 ft aFP	19.4 ft aFP	19.5 ft aFP

TASK 4

The maximum passenger load that passes the simplified stability test was calculated for each of the conditions in Task 3. In addition, the 1979 canvas canopy conditions were analyzed in both fresh and salt water to evaluate stability in Thames River, Connecticut, where it originally operated. The simplified stability test specifies a center of hypothetical passenger weight to be located 2.5 feet above the passenger deck. For the 1964 condition only, a VCG of 1.5 feet above the deck was also considered. The 1964 condition is additionally analyzed using salt water. Because the minimum freeboard occurs further than 3/4 of the length from the bow, the reference point is taken at 3/4 of the length.

The number of 140 lb passengers (protected waters) was adjusted for each condition until the stability criteria were met. Detailed calculations are included in Appendix C.

Applicable Standards

46 CFR § 178.330 specifies the procedure and calculations for the simplified stability test.

(a) A vessel must be in the condition specified in this paragraph when a simplified stability proof test is performed.

(3) Each fuel and water tank must be approximately three-quarters full.

(4) A weight equal to the total weight of all passengers, crew, and other loads permitted on the vessel must be on board and distributed so as to provide normal operating trim and to simulate the vertical center of gravity causing the least stable condition that is likely to occur in service. Unless otherwise specified, weight and vertical center of gravity is assumed to be as follows:

(ii) The weight of one person is considered to be 72.6 kilograms (160 pounds) except the weight of one person is considered to be 63.5 kilograms (140 pounds) if the vessel operates exclusively on protected waters and the passenger load consists of men, women, and children;
(iii) The vertical center for the simulated weight of passengers, crew, and other loads must be at least 760 millimeters (2.5 feet) above the deck; and

(5) All non-return closures on cockpit scuppers or on weather deck drains must be kept open during the test.

(b) A vessel must not exceed the limitations in paragraph (f) of this section, when subjected to the greater of the following heeling moments:

$M_p = (W)\ (B_p)/6$; or
$M_w = (P)\ (A)\ (H)$

where:
M_p = passenger heeling moment in kilogram-meters (foot-pounds);
W = the total passenger weight using 72.6 kilograms (160 pounds) per passenger, or, if the vessel operates exclusively on protected waters and the passenger load consists of men, women, and children, 63.5 kilograms (140 pounds) per passenger may be used;
B_p = the maximum transverse distance in meters (feet) of a deck that is accessible to passengers;
M_w = wind heeling moment in kilogram-meters (foot-pounds);
P = wind pressure of:
(1) 36.6 kilograms/square meter (7.5 pounds/square foot) for operation on protected waters;
(2) 48.8 kilogram/square meter (10.0 pounds/square foot) for operation on partially protected waters; or
(3) 73.3 kilograms/square meter (15.0 pounds/square foot) for operation on exposed waters;
A = area, in square meters (square feet), of the projected lateral surface of the vessel above the waterline (including each projected area of the hull, superstructure and area bounded by railings and structural canopies).
H = height, in meters (feet), of the center of area (A) above the waterline, measured up from the waterline.

(d) A vessel must not exceed the following limits of heel:
(1) On a flush deck vessel, not more than one-half of the freeboard may be immersed.
(6) In no case may the angle of heel exceed 14 degrees.

(e) The limits of heel must be measured at:
(1) The point of minimum freeboard; or
(2) At a point three-quarters of the vessel's length from the bow if the point of minimum freeboard is aft of this point.

(f) When demonstrating compliance with paragraph (d) of this section, the freeboard must be measured as follows:
(1) For a flush deck or well deck vessel, the freeboard must be measured to the top of the weatherdeck at the side of the vessel.

Results

Table 11 shows the maximum number of 140 lb passengers that may be carried in each lightship condition if the simplified stability criterion is to be met. Because of the wind heel requirement, only the cases with no canopy pass, regardless of the number of passengers.

Table 11. Maximum Passenger Loading for Simplified Stability Test

Condition	Total Passenger Weight	Passengers (140 lb/pax)
1964 – VCG 2.5 ft abv deck	5,740 lb	41
1964 – VCG 1.5 ft abv deck	6,580 lb	47

There are several factors that influence the simplified stability test. The heeling moment required for the test is the greater of passenger heel and wind heel. Where passenger heel is governing, heeling moment is independent of draft and directly proportional to the number of passengers. As passengers are removed, VCG is reduced, and righting moment is correspondingly increased. Figure 5 shows heeling and righting moments for the 1964 conditions. The righting moment is shown in the upright position with deadweight positioned on centerline.

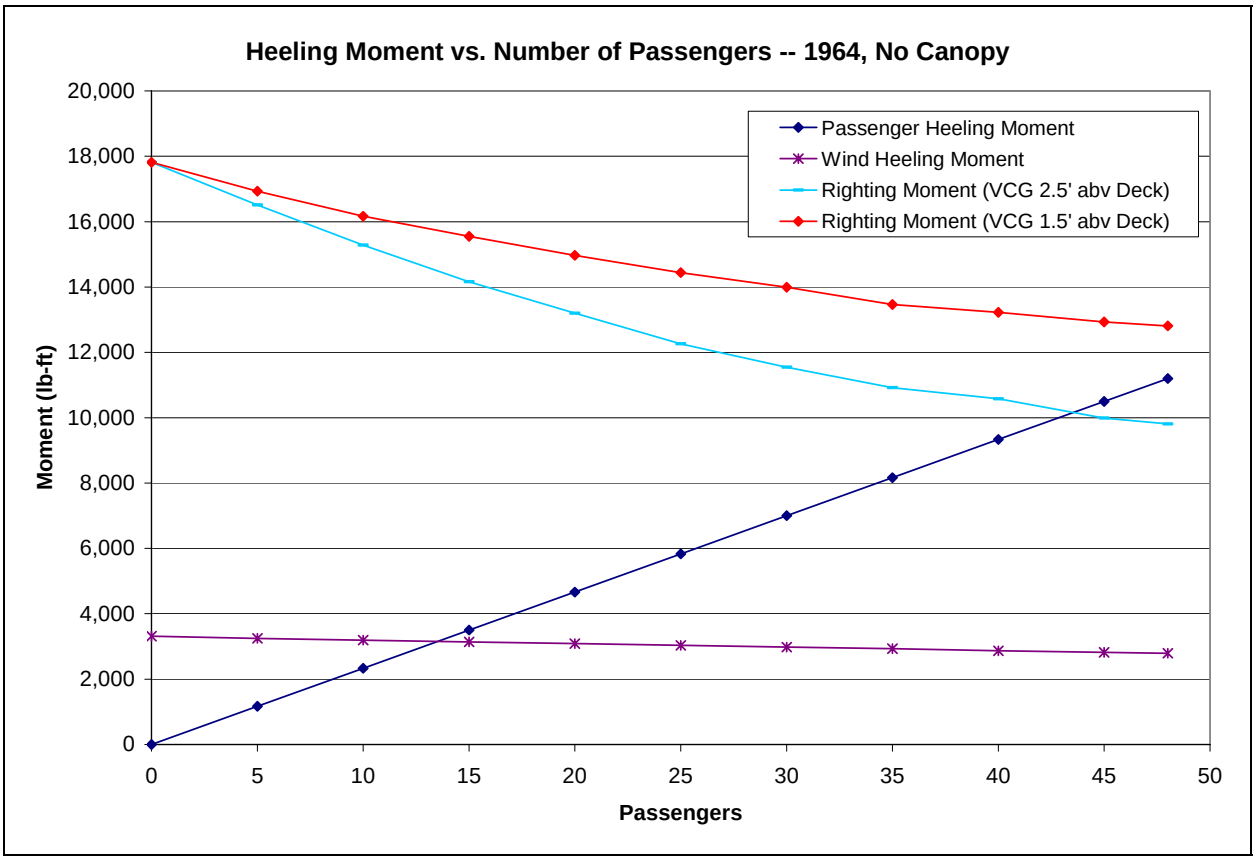

Figure 5. Heeling Moments – 1964, No Canopy

In cases where wind heel is governing, heeling moment is increased as passengers are removed. This does not correspond to increased passenger load being more stable, however, because as passengers are added the VCG increases, and the freeboard decreases reducing the allowable heel angle. Figure 6 compares heeling moments for the 2005 condition with wooden canopy.

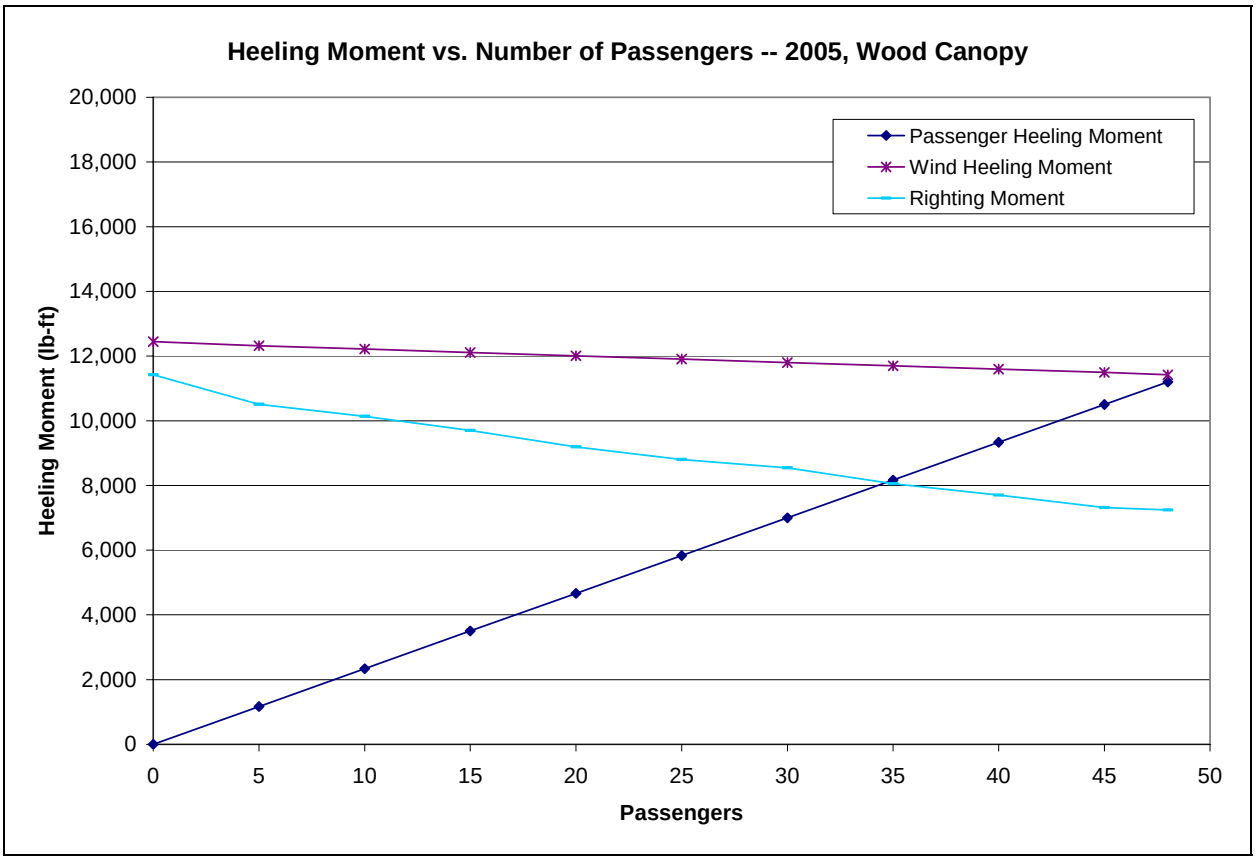

Figure 6. Heeling Moments – 2005, Wood Canopy

In all of the conditions with a canopy, the sail area must include everything below the top of the canopy whether windows are assumed to be open or closed. This results in a wind heeling moment so high that the righting moment is never sufficient to counter it.

TASK 5

The maximum passenger loading that will meet the USCG stability criteria found in 46 CFR Subchapter "S" was determined based on the vessel conditions calculated in Tasks 2 and 3. For the Subchapter S calculations, it is assumed that the center of gravity of the combined passengers is at the geometric center of the passenger benches. This is 20 inches above deck and slightly to port. It is further assumed that the 1964 vessel has no canopy. Canopy dimensions for the other arrangements are based on Reference 8.

Applicable Standards

The vessel is required to meet the applicable stability requirements specified under Subchapter T – Rules Pertaining to Small Passenger Vessels. It has been determined that the applicable requirements of Subchapter S – Subdivision and Stability the vessel is required to meet are 46 CFR § 170.170 (Weather Criteria), 46 CFR § 170.173 (Vessels of Unusual Form), and 46 CFR § 171.050 (Passenger Heel). For each standard, the stability criteria was calculated then converted to a maximum total passenger weight.

§170.170 (a) Weather Criteria

The vessel must be shown to have a GM greater than the following:

$$GM \geq \frac{PAH}{W \tan(T)}$$

Where: $P = 0.0025 + (L / 14200)^2$ tons/ft^2 for service on protected waters

L = vessel length between perpendiculars
A = projected lateral area in square feet of the portion of the vessel and deck above the waterline
H = the vertical distance from the center of A to the center of the underwater lateral area.
W = displacement
T = the lesser of 14 degrees heel or the angle of heel at which one-half the freeboard to the deck edge is immersed.

§170.173 Vessels of unusual proportion and form

The vessel was evaluated based on the criterion for vessels of unusual proportion and form. This is a righting energy criterion that is applicable to mechanically powered vessels under 100 meters in length, per 46 CFR 170.170(d).

> (e) For the purpose of demonstrating acceptable stability … compliance with paragraphs (a) through (d) of this section or the following criteria is required:
>
> (2) For protected routes, there must be –
> (i) Positive righting arms to at least 25 degrees of heel;
> (ii) No downflooding point to at least 15 degrees; and
> (iii) At least 10 foot-degrees of energy to the smallest of the following angles:
> (A) The angle of maximum righting arm.
> (B) The downflooding angle.
> (C) 40 degrees.

§171.050 Passenger heel

The vessel must be shown to have a GM greater than the following:

$$GM \geq \frac{Nb}{(K)(W)\tan(T)}$$

where –
N = number of passengers
W = displacement of the vessel in long tons
T = 14 degrees or the angle of heel at which the deck edge is first submerged, whichever is less.
b = distance in feet from the centerline of the vessel to the geometric center of the passenger deck on one side of the centerline
K = 24 passengers/long ton

Results

Table 12 shows the results of Task 5 – maximum passenger loading for Subchapter S criteria. Passenger counts are based on 140 pounds per person, the USCG standard for protected waters. As in the simplified criteria, canopy conditions do not meet the wind heel criteria regardless of passenger count. The wood canopy does meet the criteria with a reduced number of passengers. This is because the wood canopy is lower than the canvas.

Figures 7, 8 and 9 show required and actual GM for the steel, aluminum and wood canopies, based on 170.170 wind heel criteria. These graphs show that for steel and aluminum canopies, the vessel cannot meet the criteria regardless of passenger loading. The wood canopy graph is included to illustrate what the curves look like in an arrangement that meets the criteria.

Table 12. Maximum Passenger Loading for Subchapter S Stability Criteria

	170.170 Wind Heel		170.173 Unusual Form		171.050 Passenger Heel	
Condition	**Total Passenger Weight**	**Passengers (140 lb/pax)**	**Total Passenger Weight**	**Passengers (140 lb/pax)**	**Total Passenger Weight**	**Passengers (140 lb/pax)**
1964 – as delivered	>21,000	>150	8,260	59	8,120	58
1979 – Steel Canopy – SW	FAIL		1,540	11	6,860	49
1979 – Steel Canopy – FW	FAIL		1,400	10	6,720	48
1979 – Al Canopy – SW	FAIL		5,180	37	7,560	54
1979 – Al Canopy – FW	FAIL		5,040	36	7,560	54
2005 – Wood Canopy	2,940	21	1,960	14	6,860	49

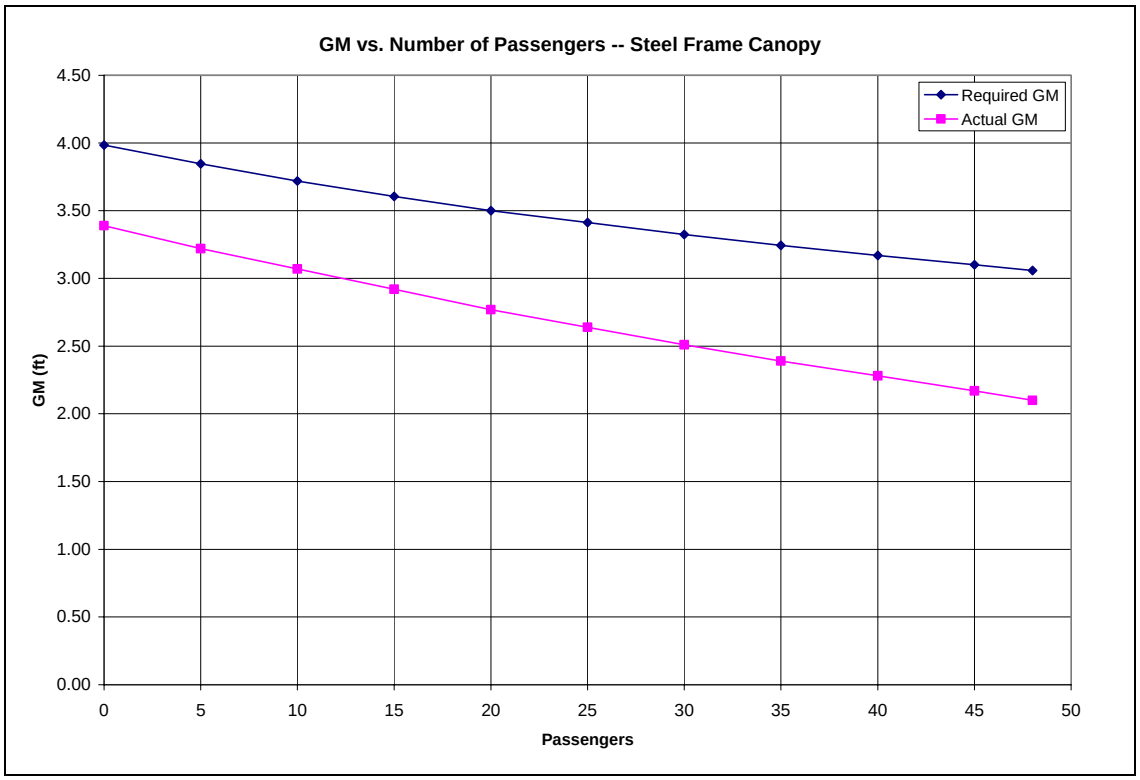

Figure 7. GM vs. Passengers – Steel Canopy

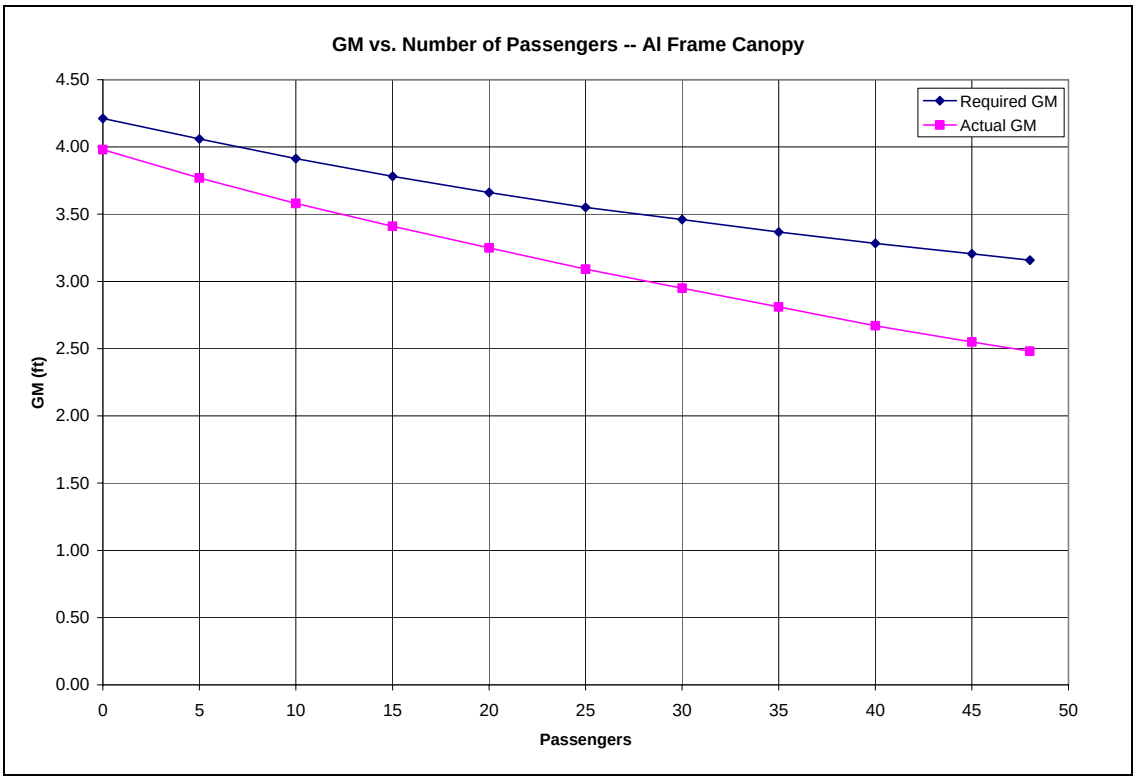

Figure 8. GM vs. Passengers – Aluminum Canopy

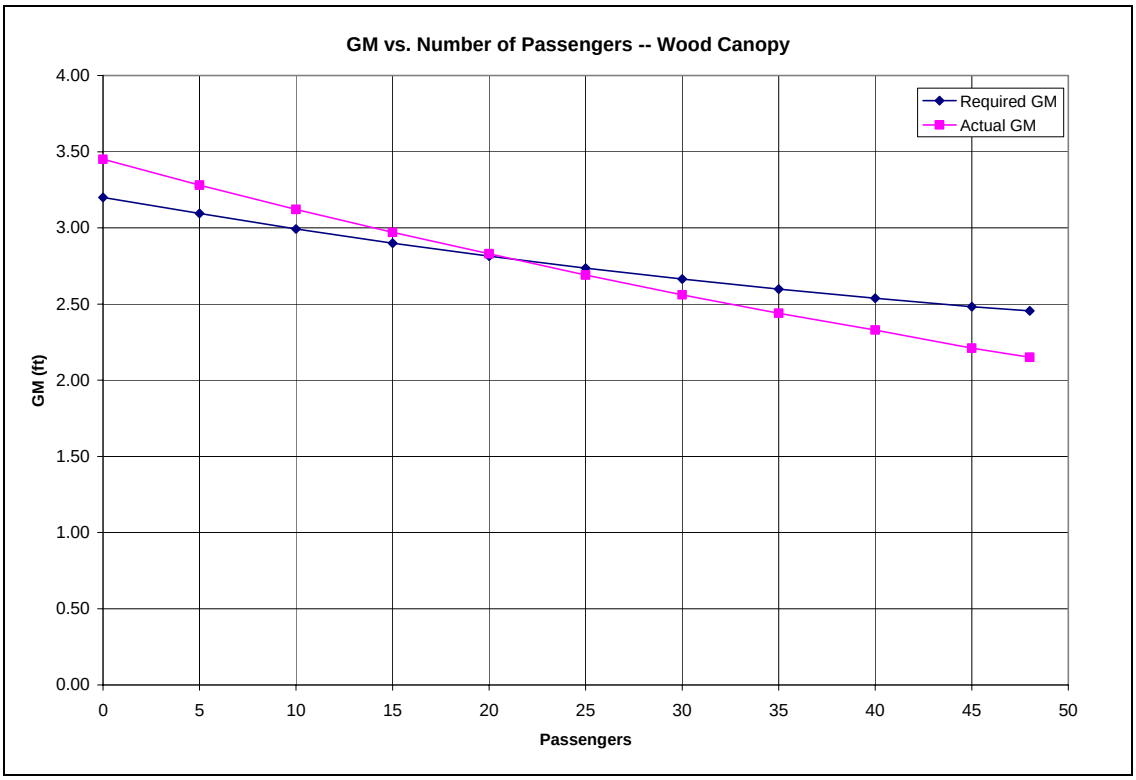

Figure 9. GM vs. Passengers – Wood Canopy

Because of the heavier weight and higher center of gravity, the steel and wood canopy configurations require a substantially reduced passenger load to pass the unusual form criteria. The governing criterion is the righting energy of 10 ft-deg up to the maximum GZ. The GZ curve of these arrangements is relatively flat, and the righting energy with 48 passengers is approximately 5 ft-deg.

All of the conditions pass the passenger heeling moment criterion. The maximum number of passengers that can be carried is calculated as only somewhat higher than the 48 certified. The highest being 58 passengers in the 1964 condition.

APPENDIX A

ETHAN ALLEN INVESTIGATION
DELIVERABLE 1: TASKS 1 - 5

HECSALV COMPUTER MODEL

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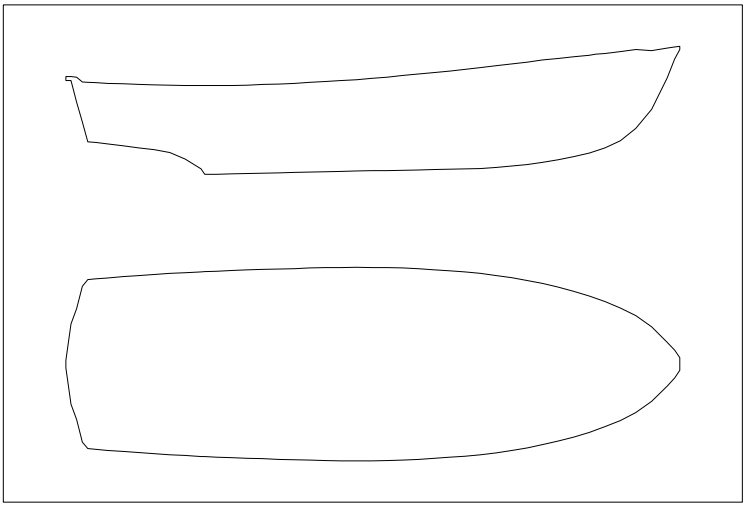
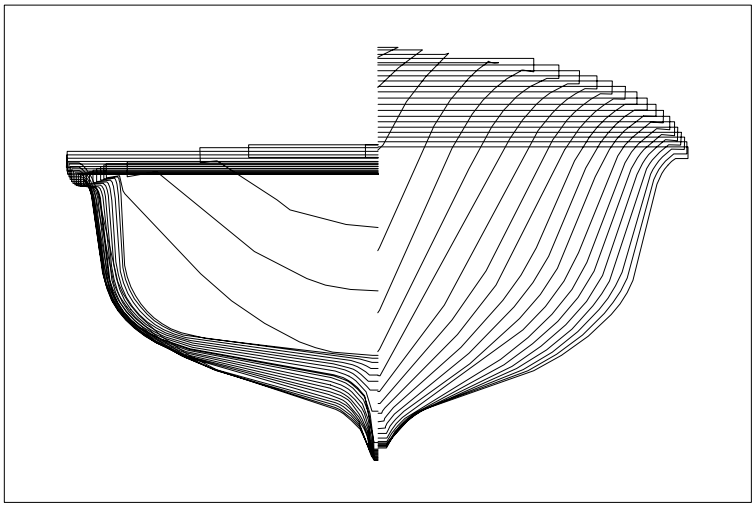
HULL SUMMARY

Profile/Plan



Body Plan



HULL SUMMARY

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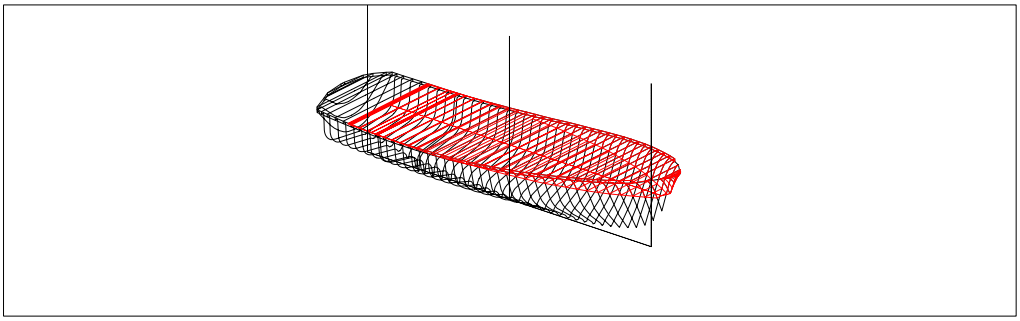
Compartment Properties - Hull

HULL SUMMARY



Properties

Plate Thick	in	0.0
App Allow		0.000
Height Margin	in	0.0
Aft	ft-FP	36.44A
Fwd		3.05F
Lower	ft-BL	-0.22
Upper		8.00
Port	ft-CL	6.21P
Stbd		6.21S

Displacement at Custom Keel Draft=2.46Ft

	Volume	LCB	KB	TCB
	ft3	ft-FP	ft-BL	ft-CL
Molded Offsets	240	18.81A	1.82	0.00
+ Added Compartments	---	---	---	---
- Subtracted Compartments	---	---	---	---
+ Added Volumes	---	---	---	---
+ Shell Plating	---	---	---	---
+ Appendage Allowance	---	---	---	---
Total Volume	240	18.81A	1.82	0.00
Displacement				
in Salt Water (0.029LT/ft3)	15,389 lbs			
in Fresh Water (0.028LT/ft3)	15,013 lbs			

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HULL SUMMARY (CONT.)

Subtracted Compartments

			Calculated Full Properties				Long Bounds		Vert Bounds		Trans Bounds	
*	Name	Perm	Capacity	LCG	VCG	TCG	Aft	Fwd	Lower	Upper	Port	Stbd
			ft3	ft-FP	ft-BL	ft-CL	ft-FP	ft-FP	ft-BL	ft-BL	ft-CL	ft-CL
	DECK	1.000	233	8.42A	6.19	0.00S	31.13A	3.05F	5.46	8.00	6.21P	6.21S
	TOTALS	1.000	233	8.42A	6.19	0.00S	31.13A	3.05F	5.46	8.00	6.21P	6.21S

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TABLE OF OFFSETS

No.	1			2			3			4			5			6			7			8
Long (ft-FP)	36.44A			36.13A			35.76A			35.39A			35.03A			34.50A			33.76A			32.76A
Sym	Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			ymmetri
lRule				SR-L			SR-R			SR-L			SR-R			SR-L			SR-R			SR-L
	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans
	ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL
1	0.00	5.81	C0	0.00	5.81	C0	0.00	4.42		0.00	3.15		0.00	1.87		0.00	1.81		0.00	1.73		0.00
2	0.25S	5.81	C1	2.58S	5.81	C1	0.63S	4.47		0.54S	3.18		0.10S	1.87		0.11S	1.81		0.12S	1.73		0.14S
3	0.25S	6.06	C2	2.58S	6.06	C2	1.75S	4.76		1.05S	3.27		0.90S	1.94		3.42S	2.20		0.36S	1.80		0.23S
4	0.00	6.06	C3	0.00	6.06	C3	2.01S	4.97		1.42S	3.40		1.25S	2.02		3.92S	2.32		3.88S	2.27		0.33S
5							3.21S	5.74		2.46S	3.94		1.57S	2.14		4.13S	2.40		4.10S	2.35		0.54S
6							3.55S	5.70	C1	4.42S	5.52		2.26S	2.51		4.31S	2.50		4.29S	2.45		3.83S
7							3.55S	6.00	C2	5.00S	5.42	C1	2.92S	2.95		4.46S	2.62		4.46S	2.56		4.07S
8							0.00	6.00		5.00S	5.72	C2	3.53S	3.49		4.60S	2.75		4.60S	2.69		4.27S
9										0.00	5.72		5.05S	5.08		4.73S	2.89		4.74S	2.83		4.45S
10													5.07S	5.12		4.84S	3.06		4.85S	3.00		4.60S
11													5.08S	5.14		4.93S	3.24		4.95S	3.18		4.75S
12													5.08S	5.15		5.00S	3.44		5.03S	3.38		4.88S
13													5.09S	5.15		5.05S	3.66		5.09S	3.61		4.99S
14													5.16S	5.45		5.12S	5.08		5.18S	5.05		5.08S
15													5.42S	5.40	C1	5.15S	5.31		5.20S	5.28		5.14S
16													5.42S	5.69	C2	5.16S	5.35		5.22S	5.32		5.24S
17													0.00	5.69		5.17S	5.38		5.23S	5.35		5.28S
18																5.18S	5.40		5.23S	5.37		5.29S
19																5.18S	5.41		5.24S	5.38		5.30S
20																5.19S	5.42		5.25S	5.39		5.31S
21																5.20S	5.42		5.25S	5.39		5.32S
22																5.20S	5.42		5.26S	5.40		5.33S
23																5.46S	5.38	C1	5.53S	5.36	C1	5.34S
24																5.47S	5.66	C2	5.53S	5.63	C2	5.61S
25																0.00	5.66		0.00	5.63		5.61S
26																						0.00
27																						
28																						
29																						
30																						
31																						
32																						

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No.	8		9			10			11			12			13			14			15	
Long (ft-FP)	32.76A		31.76A			30.76A			29.76A			28.76A			27.76A			27.51A			26.76A	
Sym	Symmetric		Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric	
IRule	SR-L		SR-R			SR-L			SR-R			SR-L			SR-R			SR-L			SR-R	
	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert
	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL
1	1.61		0.00	1.47		0.00	1.35		0.00	1.18		0.00	0.76		0.00	0.13		0.00	-0.22		0.00	-0.21
2	1.61		0.17S	1.47		0.19S	1.35		0.16S	1.18		0.12S	0.76		0.08S	0.13		0.08S	-0.22		0.09S	-0.21
3	1.66		0.25S	1.54		0.34S	1.49		0.22S	1.24		0.24S	1.15		0.26S	1.06		0.09S	0.13		0.11S	0.28
4	1.70		0.33S	1.60		0.41S	1.55		0.36S	1.40		0.44S	1.36		0.41S	1.23		0.16S	0.71		0.19S	0.72
5	1.76		0.41S	1.64		0.49S	1.59		0.43S	1.46		0.51S	1.41		0.54S	1.34		0.27S	1.04		0.28S	0.98
6	2.22		0.50S	1.68		0.58S	1.63		0.50S	1.50		0.58S	1.45		0.61S	1.39		0.40S	1.19		0.50S	1.21
7	2.30		0.70S	1.73		0.89S	1.70		0.57S	1.54		0.66S	1.49		0.69S	1.42		0.53S	1.31		0.57S	1.27
8	2.38		3.74S	2.17		3.70S	2.12		0.65S	1.58		0.86S	1.56		0.89S	1.49		0.60S	1.35		0.64S	1.31
9	2.49		4.01S	2.24		4.22S	2.27		0.86S	1.63		3.70S	2.03		3.74S	2.00		0.68S	1.39		0.73S	1.35
10	2.61		4.24S	2.32		4.44S	2.37		3.70S	2.07		4.26S	2.21		4.30S	2.19		0.88S	1.46		0.94S	1.42
11	2.75		4.43S	2.42		4.62S	2.49		4.24S	2.24		4.49S	2.31		4.54S	2.30		3.77S	2.00		3.79S	1.97
12	2.92		4.60S	2.53		4.79S	2.62		4.46S	2.34		4.69S	2.43		4.75S	2.43		4.33S	2.19		4.35S	2.17
13	3.10		4.76S	2.67		4.93S	2.78		4.66S	2.46		4.87S	2.57		4.92S	2.57		4.56S	2.30		4.58S	2.29
14	3.31		4.90S	2.84		5.05S	2.96		4.82S	2.59		5.01S	2.73		5.07S	2.73		4.76S	2.43		4.78S	2.42
15	3.55		5.01S	3.02		5.15S	3.17		4.97S	2.75		5.14S	2.91		5.19S	2.92		4.93S	2.57		4.96S	2.57
16	5.00		5.11S	3.23		5.22S	3.41		5.09S	2.93		5.23S	3.13		5.28S	3.13		5.08S	2.74		5.11S	2.73
17	5.23		5.18S	3.47		5.27S	3.68		5.19S	3.14		5.31S	3.37		5.35S	3.38		5.20S	2.93		5.23S	2.92
18	5.27		5.23S	3.73		5.38S	5.06		5.26S	3.38		5.49S	5.02		5.54S	5.01		5.30S	3.14		5.32S	3.14
19	5.31		5.30S	4.95		5.40S	5.16		5.32S	3.64		5.51S	5.12		5.57S	5.11		5.36S	3.39		5.39S	3.39
20	5.33		5.34S	5.19		5.41S	5.21		5.43S	5.03		5.53S	5.16		5.58S	5.15		5.55S	5.01		5.59S	5.00
21	5.34		5.35S	5.24		5.43S	5.24		5.46S	5.14		5.54S	5.18		5.60S	5.18		5.58S	5.11		5.62S	5.10
22	5.35		5.37S	5.27		5.44S	5.26		5.47S	5.18		5.55S	5.19		5.61S	5.19		5.60S	5.15		5.63S	5.14
23	5.36		5.38S	5.29		5.45S	5.27		5.49S	5.22		5.56S	5.21		5.62S	5.20		5.61S	5.18		5.65S	5.18
24	5.33	C1	5.39S	5.30		5.46S	5.28		5.50S	5.23		5.57S	5.22		5.63S	5.21		5.62S	5.19		5.66S	5.19
25	5.59	C2	5.40S	5.31		5.47S	5.29		5.51S	5.24		5.57S	5.22		5.64S	5.21		5.64S	5.20		5.67S	5.20
26	5.59		5.41S	5.32		5.75S	5.28	C1	5.52S	5.25		5.58S	5.22		5.65S	5.22		5.65S	5.21		5.68S	5.21
27			5.68S	5.31	C1	5.75S	5.53	C2	5.53S	5.25		5.59S	5.23		5.92S	5.24	C1	5.65S	5.21		5.70S	5.22
28			5.68S	5.55	C2	0.00	5.53		5.53S	5.26		5.59S	5.23		5.92S	5.47	C2	5.66S	5.21		5.97S	5.24
29			0.00	5.55					5.81S	5.27	C1	5.87S	5.25	C1	0.00	5.47		5.93S	5.24	C1	5.97S	5.47
30									5.81S	5.50	C2	5.87S	5.49	C2				5.93S	5.47	C2	0.00	5.47
31									0.00	5.50		0.00	5.49					0.00	5.47			
32																						

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No.	15	16			17			18			19			20			21			22		
Long (ft-FP)	6.76/	25.76A			24.76A			23.76A			22.76A			21.76A			20.76A			19.76A		
Sym	nmet	Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric		
IRule	SR-R	SR-L			SR-R			SR-L			SR-R			SR-L			SR-R			SR-L		
	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C
		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL	
1		0.00	-0.19		0.00	-0.17		0.00	-0.14		0.00	-0.12		0.00	-0.10		0.00	-0.08		0.00	-0.06	
2		0.10S	-0.19		0.11S	-0.17		0.12S	-0.14		0.13S	-0.12		0.14S	-0.10		0.15S	-0.08		0.15S	-0.06	
3		0.13S	0.24		0.18S	0.42		0.20S	0.41		0.21S	0.37		0.20S	0.25		0.21S	0.23		0.38S	0.54	
4		0.19S	0.59		0.28S	0.72		0.30S	0.67		0.31S	0.60		0.23S	0.35		0.24S	0.32		0.54S	0.72	
5		0.31S	0.90		0.32S	0.81		0.34S	0.75		0.37S	0.70		0.27S	0.45		0.28S	0.41		0.61S	0.79	
6		0.52S	1.14		0.33S	0.83		0.35S	0.77		0.54S	0.93		0.38S	0.64		0.39S	0.59		0.68S	0.84	
7		0.58S	1.19		0.46S	0.99		0.54S	0.99		0.60S	0.98		0.58S	0.88		0.51S	0.76		0.76S	0.89	
8		0.66S	1.24		0.58S	1.11		0.60S	1.05		0.67S	1.03		0.64S	0.93		0.57S	0.82		0.85S	0.93	
9		0.74S	1.28		0.65S	1.16		0.67S	1.09		0.74S	1.07		0.70S	0.98		0.63S	0.87		3.31S	1.61	
10		0.95S	1.35		0.73S	1.20		0.75S	1.14		0.95S	1.15		0.78S	1.02		0.71S	0.92		3.92S	1.86	
11		3.82S	1.94		0.94S	1.28		0.96S	1.21		3.88S	1.88		0.99S	1.09		0.79S	0.96		4.45S	2.18	
12		4.38S	2.16		3.86S	1.92		3.85S	1.89		4.42S	2.11		3.90S	1.87		3.88S	1.85		4.89S	2.53	
13		4.62S	2.28		4.41S	2.14		4.41S	2.13		4.64S	2.25		4.44S	2.13		4.43S	2.14		5.07S	2.73	
14		4.83S	2.42		4.64S	2.27		4.65S	2.26		4.85S	2.41		4.67S	2.28		4.66S	2.30		5.21S	2.93	
15		5.00S	2.57		4.84S	2.41		4.85S	2.41		5.03S	2.58		4.87S	2.44		4.87S	2.47		5.33S	3.16	
16		5.15S	2.74		5.02S	2.57		5.03S	2.57		5.18S	2.77		5.05S	2.62		5.05S	2.65		5.42S	3.41	
17		5.26S	2.93		5.17S	2.75		5.18S	2.76		5.31S	2.98		5.20S	2.82		5.20S	2.85		5.67S	4.93	
18		5.35S	3.15		5.29S	2.95		5.30S	2.96		5.41S	3.21		5.33S	3.03		5.33S	3.08		5.73S	5.18	
19		5.47S	3.67		5.38S	3.17		5.40S	3.19		5.48S	3.47		5.42S	3.27		5.42S	3.32		5.77S	5.29	
20		5.62S	5.00		5.45S	3.42		5.47S	3.44		5.68S	4.96		5.49S	3.54		5.54S	3.90		5.82S	5.37	
21		5.65S	5.10		5.66S	5.01		5.66S	4.92		5.71S	5.08		5.70S	5.03		5.72S	5.10		5.85S	5.41	
22		5.67S	5.15		5.69S	5.12		5.69S	5.04		5.75S	5.19		5.74S	5.14		5.76S	5.21		5.88S	5.44	
23		5.69S	5.18		5.71S	5.16		5.72S	5.15		5.78S	5.23		5.78S	5.24		5.80S	5.30		5.91S	5.46	
24		5.72S	5.21		5.73S	5.20		5.75S	5.19		5.80S	5.27		5.80S	5.28		5.83S	5.34		5.92S	5.47	
25		5.73S	5.23		5.76S	5.23		5.77S	5.23		5.83S	5.30		5.83S	5.32		5.85S	5.37		5.94S	5.48	
26		5.74S	5.24		5.77S	5.25		5.79S	5.26		5.84S	5.31		5.86S	5.35		5.88S	5.40		6.19S	5.47	C1
27		6.01S	5.25	C1	5.78S	5.26		5.82S	5.29		5.86S	5.32		5.87S	5.36		5.90S	5.41		6.19S	5.73	C2
28	C1	6.01S	5.48	C2	6.05S	5.26	C1	6.08S	5.29	C1	6.11S	5.33	C1	5.89S	5.37		5.92S	5.42		0.00	5.73	
29	C2	0.00	5.48		6.05S	5.50	C2	6.08S	5.54	C2	6.10S	5.58	C2	6.14S	5.37	C1	6.16S	5.42	C1			
30					0.00	5.50		0.00	5.54		0.00	5.58		6.13S	5.62	C2	6.16S	5.68	C2			
31														0.00	5.62		0.00	5.68				
32																						

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No.	23			24			25			26			27			28			29			30
Long (ft-FP)	18.76A			17.76A			16.76A			15.76A			14.76A			13.76A			12.76A			11.76A
Sym	Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			ymmetri
IRule	SR-R			SR-L			SR-R			SR-L			SR-R			SR-L			SR-R			SR-L
	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans
	ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL
1	0.00	-0.04		0.00	-0.02		0.00	0.00		0.00	0.03		0.00	0.05		0.00	0.07		0.00	0.09		0.00
2	0.16S	-0.04		0.17S	-0.02		0.17S	0.00		0.17S	0.03		0.18S	0.05		0.18S	0.07		0.18S	0.09		0.18S
3	0.37S	0.49		0.36S	0.44		0.35S	0.40		0.34S	0.35		0.33S	0.31		0.31S	0.27		0.28S	0.23		0.25S
4	0.54S	0.67		0.53S	0.62		0.53S	0.58		0.66S	0.66		0.62S	0.60		0.59S	0.57		0.55S	0.54		0.37S
5	0.69S	0.79		0.68S	0.74		0.68S	0.70		0.82S	0.76		0.77S	0.71		0.73S	0.68		0.67S	0.65		0.50S
6	0.76S	0.84		0.76S	0.79		0.76S	0.75		3.11S	1.57		0.97S	0.82		0.93S	0.79		0.85S	0.75		0.65S
7	0.85S	0.88		0.85S	0.83		0.85S	0.80		3.66S	1.87		2.99S	1.57		2.90S	1.59		2.76S	1.61		0.85S
8	3.22S	1.56		3.27S	1.58		3.19S	1.57		4.19S	2.26		3.56S	1.89		3.48S	1.93		3.36S	1.98		2.67S
9	3.85S	1.84		3.85S	1.87		3.77S	1.87		4.65S	2.68		4.08S	2.28		3.99S	2.34		3.87S	2.39		3.25S
10	4.39S	2.17		4.39S	2.23		4.31S	2.25		4.83S	2.89		4.51S	2.70		4.41S	2.78		4.29S	2.85		3.75S
11	4.84S	2.55		4.84S	2.63		4.76S	2.66		4.97S	3.12		4.69S	2.92		4.59S	3.01		4.47S	3.09		4.16S
12	5.02S	2.75		5.01S	2.83		4.94S	2.87		5.09S	3.36		4.84S	3.15		4.74S	3.25		4.62S	3.35		4.48S
13	5.17S	2.96		5.15S	3.05		5.08S	3.09		5.57S	5.27		4.97S	3.41		4.87S	3.52		5.36S	5.58		5.16S
14	5.29S	3.20		5.26S	3.28		5.19S	3.33		5.66S	5.49		5.50S	5.37		5.43S	5.47		5.41S	5.67		5.27S
15	5.39S	3.46		5.64S	5.10		5.61S	5.18		5.72S	5.58		5.55S	5.47		5.48S	5.57		5.48S	5.76		5.33S
16	5.66S	5.01		5.73S	5.33		5.70S	5.40		5.78S	5.66		5.60S	5.57		5.54S	5.66		5.62S	5.91		5.40S
17	5.73S	5.25		5.78S	5.42		5.76S	5.50		5.86S	5.73		5.66S	5.66		5.60S	5.74		5.80S	6.06		5.55S
18	5.78S	5.35		5.83S	5.50		5.82S	5.58		5.94S	5.79		5.73S	5.74		5.68S	5.82		6.04S	6.05	C1	5.74S
19	5.83S	5.44		5.86S	5.54		5.89S	5.64		6.19S	5.79	C1	5.90S	5.88		5.85S	5.97		6.05S	6.31	C2	5.98S
20	5.86S	5.47		5.90S	5.57		5.96S	5.70		6.19S	6.02	C2	6.16S	5.88	C1	6.11S	5.97	C1	0.00	6.31		5.98S
21	5.89S	5.50		5.93S	5.60		6.20S	5.70	C1	0.00	6.02		6.16S	6.12	C2	6.12S	6.22	C2				0.00
22	5.92S	5.52		5.96S	5.62		6.20S	5.93	C2				0.00	6.12		0.00	6.22					
23	5.96S	5.54		6.21S	5.61	C1	0.00	5.93														
24	6.21S	5.54	C1	6.21S	5.86	C2																
25	6.20S	5.79	C2	0.00	5.86																	
26	0.00	5.79																				
27																						
28																						
29																						
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No.	30		31			32			33			34			35			36			37	
Long (ft-FP)	11.76A		10.76A			9.76A			8.76A			7.76A			6.76A			5.76A			4.76A	
Sym	Symmetric		Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric	
IRule	SR-L		SR-R			SR-L			SR-R			SR-L			SR-R			SR-L			SR-R	
	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert
	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL
1	0.11		0.00	0.13		0.00	0.16		0.00	0.22		0.00	0.31		0.00	0.41		0.00	0.55		0.00	0.72
2	0.11		0.18S	0.13		0.18S	0.16		0.18S	0.22		0.17S	0.31		0.15S	0.43		0.12S	0.56		0.07S	0.72
3	0.20		0.21S	0.17		0.28S	0.32		0.27S	0.38		0.20S	0.39		0.15S	0.44		0.12S	0.58		0.07S	0.72
4	0.36		0.43S	0.46		0.39S	0.47		0.36S	0.51		0.25S	0.46		0.15S	0.45		0.14S	0.61		0.08S	0.73
5	0.50		0.56S	0.59		0.54S	0.61		0.49S	0.64		0.30S	0.54		0.16S	0.48		0.18S	0.68		0.08S	0.74
6	0.63		0.73S	0.72		2.45S	1.79		2.89S	2.37		0.36S	0.61		0.18S	0.51		0.31S	0.83		0.09S	0.76
7	0.76		2.51S	1.68		2.99S	2.23		3.34S	2.84		0.52S	0.76		0.20S	0.54		1.66S	2.03		0.14S	0.82
8	1.65		3.09S	2.10		3.47S	2.69		3.71S	3.35		1.83S	1.70		0.33S	0.70		2.49S	2.96		1.58S	2.28
9	2.05		3.59S	2.55		3.87S	3.18		4.00S	3.91		2.83S	2.60		1.82S	1.91		2.85S	3.47		2.35S	3.27
10	2.48		3.99S	3.02		4.16S	3.72		4.78S	5.84		3.24S	3.08		2.71S	2.83		3.16S	4.01		3.73S	5.96
11	2.94		4.31S	3.55		4.93S	5.70		4.92S	6.04		3.58S	3.60		3.09S	3.32		3.92S	5.74		4.01S	6.38
12	3.45		5.05S	5.58		5.06S	5.92		5.07S	6.21		4.33S	5.42		3.41S	3.84		4.22S	6.22		4.17S	6.56
13	5.46		5.17S	5.80		5.20S	6.08		5.44S	6.51		4.62S	5.97		4.14S	5.59		4.38S	6.42		4.33S	6.71
14	5.69		5.24S	5.89		5.56S	6.38		5.69S	6.50	C1	4.76S	6.17		4.43S	6.10		4.54S	6.58		4.51S	6.85
15	5.78		5.31S	5.97		5.82S	6.36	C1	5.69S	6.74	C2	4.92S	6.34		4.59S	6.30		4.72S	6.73		4.70S	6.98
16	5.86		5.66S	6.26		5.82S	6.63	C2	0.00	6.74		5.30S	6.63		4.75S	6.47		4.93S	6.87		4.93S	6.97
17	6.01		5.91S	6.24	C1	0.00	6.63					5.55S	6.63	C1	4.92S	6.62		5.17S	6.86	C1	4.94S	7.22
18	6.16		5.91S	6.52	C2							5.55S	6.87	C2	5.12S	6.75		5.17S	7.11	C2	0.00	7.22
19	6.14	C1	0.00	6.52								0.00	6.87		5.37S	6.75	C1	0.00	7.11			
20	6.41	C2													5.37S	6.99	C2					
21	6.41														0.00	6.99						
22																						
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No.	37	38			39			40			41			42			43			44		
Long (ft-FP)	3.76A	3.76A			2.76A			1.76A			0.76A			0.24F			1.24F			2.24F		
Sym	nmet	Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric			Symmetric		
IRule	SR-R	SR-L			SR-R			SR-L			SR-R			SR-L			SR-R			SR-L		
	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C	Trans	Vert	C
		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL		ft-CL	ft-BL	
1		0.00	0.91		0.00	1.15		0.00	1.47		0.00	1.94		0.00	2.71		0.00	3.95		0.00	5.96	
2		0.04S	0.91		0.03S	1.15		0.04S	1.46		0.03S	1.99		0.03S	2.77		0.03S	4.01		0.10S	6.06	
3		1.48S	2.57		1.32S	2.87		2.63S	6.18		1.82S	5.58		1.48S	5.99		1.12S	6.44		0.57S	6.91	
4		2.15S	3.55		3.20S	6.35		2.88S	6.56		2.26S	6.41		1.87S	6.66		1.44S	6.96		0.95S	7.41	
5		3.48S	6.16		3.47S	6.69		3.15S	6.86		2.51S	6.74		2.09S	6.94		1.80S	7.38		1.41S	7.88	
6		3.76S	6.54		3.61S	6.83		3.29S	6.98		2.77S	7.02		2.32S	7.18		1.99S	7.56		1.34S	7.86	C1
7		3.91S	6.70		3.77S	6.96		3.44S	7.09		2.90S	7.13		2.57S	7.37		2.20S	7.71		0.00	7.86	
8		4.07S	6.84		3.94S	7.08		3.78S	7.27		3.05S	7.22		2.85S	7.53		2.20S	7.71				
9		4.24S	6.96		4.13S	7.18		4.02S	7.27	C1	3.37S	7.38		2.85S	7.53		2.20S	7.72				
10		4.43S	7.08		4.37S	7.17	C1	4.02S	7.54	C2	3.61S	7.38	C1	2.85S	7.53		2.20S	7.72				
11		4.67S	7.07	C1	4.37S	7.43	C2	0.00	7.54		3.61S	7.65	C2	2.85S	7.53		2.20S	7.72				
12		4.67S	7.33	C2	0.00	7.43					0.00	7.65		2.85S	7.53		2.20S	7.72				
13		0.00	7.33											2.85S	7.54		2.20S	7.72				
14														2.85S	7.54		2.20S	7.72				
15														2.85S	7.54		2.20S	7.72				
16	C1													2.85S	7.54		2.20S	7.72				
17	C2													2.85S	7.54		2.20S	7.72				
18														2.85S	7.54		2.20S	7.72				
19														2.85S	7.54		2.20S	7.72				
20														2.86S	7.54		2.20S	7.72				
21														2.87S	7.54		2.20S	7.72				
22														2.88S	7.55		2.20S	7.72				
23														2.89S	7.55		2.20S	7.72				
24														3.11S	7.51	C1	2.20S	7.72				
25														3.11S	7.78	C2	2.20S	7.72				
26														0.00	7.78		2.20S	7.72				
27																	2.20S	7.72				
28																	2.26S	7.70				
29																	2.29S	7.69				
30																	2.32S	7.69				
31																	2.40S	7.69	C1			
32																	0.00	7.69				

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No.	45			46		
Long (ft-FP)	2.74F			3.05F		
Sym	Symmetric			Symmetric		
IRule	SR-R			Trap		
	Trans	Vert	C	Trans	Vert	C
	ft-CL	ft-BL		ft-CL	ft-BL	
1	0.00	7.20		0.00	7.80	
2	0.41S	7.59		0.20S	7.90	
3	0.89S	7.95	C1	0.40S	8.00	C1
4	0.00	7.95		0.00	8.00	
5						
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7						
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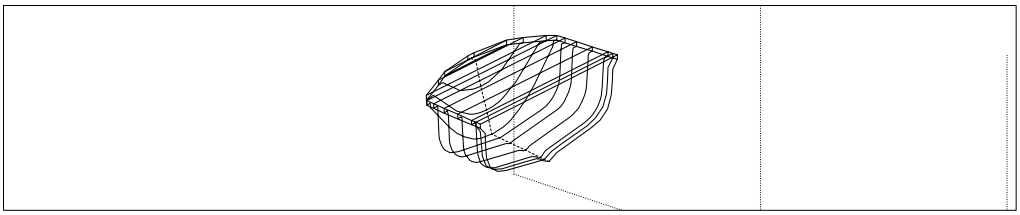
STERN

COMPARTMENT SUMMARY - STERN



Properties

Density	**LT/ft3**	0.028
Perm		1.000
IMO Type		Undefined
Aft	**ft-FP**	36.44A
Fwd		31.14A
Lower	**ft-BL**	1.40
Upper		6.06
Port	**ft-CL**	5.73P
Stbd		5.73S

Volume/FS

	Volume	LCG	VCG	TCG	FS Slack	FS 98%
	ft3	ft-FP	ft-BL	ft-CL	ft4	ft4
Molded Offsets	153	33.26A	3.94	0.00S		
+ Added Compartments	---	---	---	---		
- Subtracted Compartments	---	---	---	---		
Molded Capacity	153	33.26A	3.94	0.00S		
Capacity (Perm=1.000)	153	33.26A	3.94	0.00S	420	118
Linked Tank	153	33.26A	3.94	0.00S	420	118
Difference	0	0.00	0.00	0.00	0	0
Linked Tank Table	153	33.26A	3.94	0.00S	420	118
Difference	0	0.00	0.00	0.00	0	0

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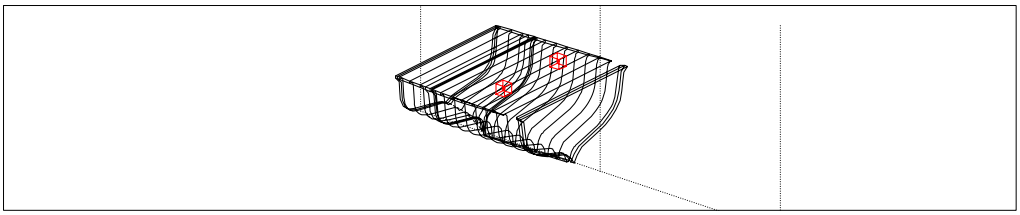
ER

COMPARTMENT SUMMARY - ER



Properties

Density	**LT/ft3**	0.028
Perm		1.000
IMO Type		Undefined
Aft	**ft-FP**	31.14A
Fwd		19.22A
Lower	**ft-BL**	-0.22
Upper		5.46
Port	**ft-CL**	6.16P
Stbd		6.16S

Volume/FS

	Volume	LCG	VCG	TCG	FS Slack	FS 98%
	ft3	**ft-FP**	**ft-BL**	**ft-CL**	**ft4**	**ft4**
Molded Offsets	487	25.00A	3.57	0.00P		
+ Added Compartments	---	---	---	---		
- Subtracted Compartments	---	---	---	---		
Molded Capacity	487	25.00A	3.57	0.00P		
Capacity (Perm=1.000)	487	25.00A	3.57	0.00P	1,420	490
Linked Tank	487	25.00A	3.57	0.00P	1,420	490
Difference	0	0.00	0.00	0.00	0	0
Linked Tank Table	487	25.00A	3.57	0.00P	1,420	490
Difference	0	0.00	0.00	0.00	0	0

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COMPARTMENT SUMMARY (CONT.)

Downflooding Points

No.	Name	Type	Long	Vert	Trans
			ft-FP	ft-BL	ft-CL
1	VENT P	Unprotected	22.89A	6.00	2.70P
2	VENT S	Unprotected	22.89A	6.00	3.50S
3					

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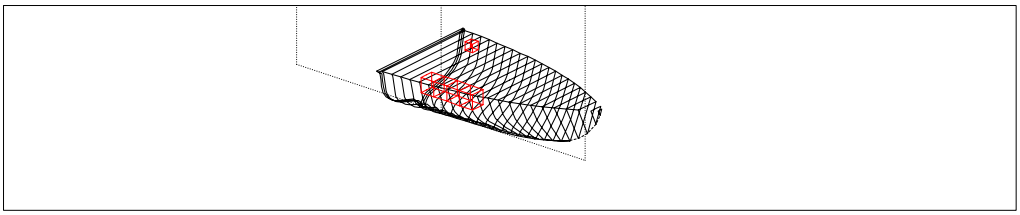
FWD

COMPARTMENT SUMMARY - FWD



Properties

Density	**LT/ft3**	0.028
Perm		1.000
IMO Type		Undefined
Aft	**ft-FP**	19.22A
Fwd		1.74F
Lower	**ft-BL**	-0.05
Upper		5.46
Port	**ft-CL**	6.13P
Stbd		6.13S

Volume/FS

	Volume	LCG	VCG	TCG	FS Slack	FS 98%
	ft3	ft-FP	ft-BL	ft-CL	ft4	ft4
Molded Offsets	565	11.79A	3.53	0.00P		
+ Added Compartments	---	---	---	---		
- Subtracted Compartments	-14	15.47A	2.46	0.00		
Molded Capacity	552	11.70A	3.56	0.00P		
Capacity (Perm=1.000)	552	11.70A	3.56	0.00P	1,196	467
Linked Tank	552	11.70A	3.56	0.00P	1,196	467
Difference	0	0.00	0.00	0.00	0	0
Linked Tank Table	552	11.70A	3.56	0.00P	1,196	467
Difference	0	0.00	0.00	0.00	0	0

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FWD

COMPARTMENT SUMMARY (CONT.)

Subtracted Compartments

			Calculated Full Properties				Long Bounds		Vert Bounds		Trans Bounds	
*	Name	Perm	Capacity	LCG	VCG	TCG	Aft	Fwd	Lower	Upper	Port	Stbd
			ft3	ft-FP	ft-BL	ft-CL	ft-FP	ft-FP	ft-BL	ft-BL	ft-CL	ft-CL
	FUEL	1.000	14	15.47A	2.46	0.00	18.47A	12.47A	1.71	3.21	0.75P	0.75S
	TOTALS	1.000	14	15.47A	2.46	0.00	18.47A	12.47A	1.71	3.21	0.75P	0.75S

Downflooding Points

No.	Name	Type	Long	Vert	Trans
			ft-FP	ft-BL	ft-CL
1	VENT	Unprotected	15.39A	6.00	2.70P
2					

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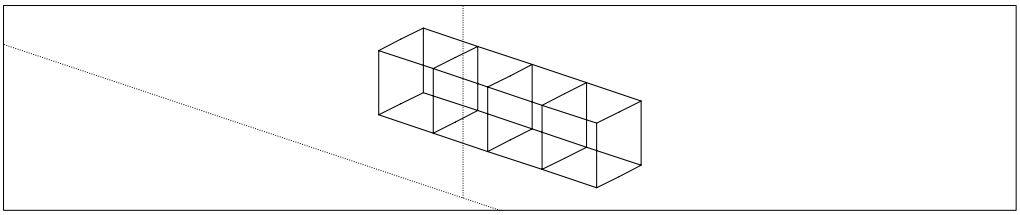
FUEL

COMPARTMENT SUMMARY - FUEL



Properties

Density	**LT/ft3**	0.028
Perm		1.000
IMO Type		Undefined
Aft	**ft-FP**	18.47A
Fwd		12.47A
Lower	**ft-BL**	1.71
Upper		3.21
Port	**ft-CL**	0.75P
Stbd		0.75S

Volume/FS

	Volume	LCG	VCG	TCG	FS Slack	FS 98%
	ft3	ft-FP	ft-BL	ft-CL	ft4	ft4
Molded Offsets	14	15.47A	2.46	0.00		
+ Added Compartments	---	---	---	---		
- Subtracted Compartments	---	---	---	---		
Molded Capacity	14	15.47A	2.46	0.00		
Capacity (Perm=1.000)	14	15.47A	2.46	0.00	2	1
Linked Tank	14	15.47A	2.46	0.00	2	1
Difference	0	0.00	0.00	0.00	0	0
Linked Tank Table	14	15.47A	2.46	0.00	2	1
Difference	0	0.00	0.00	0.00	0	0

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Appended Compartments (2)

Appended Compartments

				Auto		Offsets		Long Bounds		Vert Bounds		ns Bou
Name	Short Name	Density	Perm	Plan	Profile	Generated?	IRule	Aft	Fwd	Lower	Upper	Port
		LT/ft3						ft-FP	ft-FP	ft-BL	ft-BL	ft-CL
FUEL	FUEL	0.028	1.000	Yes	Yes	Yes	Trap	18.47A	12.47A	1.71	3.21	0.75P
DECK	DECK	0.028	1.000	Yes	Yes	Yes	Simp	31.13A	3.05F	5.46	8.00	6.21P
TOTALS												

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Appended Compartments (2)

	ns Bou	Calc Settings			Capacity	100% Full Center			Free Surface		l Tank Prop
Name	Stbd	Tolerance	Precision	Vol Tolerance	Perm	LCG	VCG	TCG	Slack	98% Full	Capacity
	ft-CL			ft3	ft3	ft-FP	ft-BL	ft-CL	ft4	ft4	ft3
FUEL	0.75S	0.000	2	0	14	15.47A	2.46	0.00	2	1	---
DECK	6.21S	0.000	2	0	233	8.42A	6.19	0.00S	1,428	88	---
TOTALS					246	8.81A	5.99	0.00S	1,430	90	---

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Appended Compartments (2)

	Linked Tank Properties			Difference					
Name	**LCG**	**VCG**	**TCG**	**Capacity**	**LCG**	**VCG**	**TCG**	**Last Updated**	**Notes**
	ft-FP	**ft-BL**	**ft-CL**	**ft3**	**Ft**	**Ft**	**Ft**		
FUEL	16.76A	---	---	---	---	---	---	3/2/2006 12:13:41 PM	
DECK	16.76A	---	---	---	---	---	---	3/2/2006 12:09:28 PM	
TOTALS	---	---	---	---	---	---	---		

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Lightship

LIGHTSHIP SUMMARY

Lightship

	Magnitude	Center			
Name	**Weight**	**LCG**	**VCG**	**TCG**	**FS**
	lbs	**ft-MS**	**ft-BL**	**ft-CL**	**ft-LT**
Lightship	12,759	2.64A	4.46	0.00	---
Constant	0	0.00	0.00	0.00	---
TOTALS	12,759	2.64A	4.46	0.00	---

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Hull

HYDROSTATIC TABLE - HULL

Options

Density	**LT/ft3**	0.029
Long Draft Ref		LCF
Trim	**ft**	0.00
Heel	**deg**	0
Master Draft		Baseline

Hydrostatic Properties

	Draft		Buoyancy			Metacenter	Waterplane				Wetted	Waterplane
No.	**Keel**	**Ref**	**Disp**	**LCB**	**KB**	**KMt**	**LCF**	**MT1**	**LWL**	**TP1**	**Surface**	**Area**
	Ft	**ft-BL**	**lbs**	**ft-FP**	**Ft**	**Ft**	**ft-FP**	**ft-LT/in**	**Ft**	**LT/in**	**ft2**	**ft2**
1	0.00	0.00	19	23.53A	-0.07	0.01	21.84A	0.00	10.72	0.01	5.1	3.0
2	0.25	0.25	119	19.34A	0.11	0.21	17.07A	0.02	19.48	0.02	17.1	8.9
3	0.50	0.50	310	17.50A	0.28	0.46	15.96A	0.03	22.24	0.04	30.1	15.3
4	0.75	0.75	633	16.55A	0.46	0.86	15.32A	0.05	24.15	0.06	46.4	25.8
5	1.00	1.00	1,191	15.95A	0.66	1.79	15.32A	0.10	25.93	0.11	70.6	45.5
6	1.25	1.25	2,126	15.80A	0.87	3.13	15.91A	0.18	27.72	0.17	101.6	72.6
7	1.50	1.50	3,560	16.04A	1.08	4.75	16.89A	0.31	30.27	0.26	140.6	108.0
8	1.75	1.75	5,622	16.59A	1.28	6.28	18.21A	0.55	32.78	0.36	187.3	150.9
9	2.00	2.00	8,449	17.44A	1.48	7.75	19.83A	0.92	34.38	0.48	242.3	201.7
10	2.25	2.25	12,010	18.29A	1.67	8.65	20.60A	1.21	34.78	0.57	286.5	240.7
11	2.50	2.50	16,060	18.88A	1.85	8.54	20.64A	1.37	35.17	0.63	315.6	263.4
12	2.75	2.75	20,420	19.25A	2.02	8.19	20.54A	1.50	35.55	0.67	340.0	280.0
13	3.00	3.00	25,013	19.48A	2.17	7.79	20.41A	1.60	35.83	0.70	362.0	292.6
14	3.25	3.25	29,781	19.62A	2.33	7.41	20.29A	1.70	36.10	0.72	383.1	302.7
15	3.50	3.50	34,676	19.70A	2.47	7.07	20.18A	1.78	36.38	0.74	403.5	310.8
16	3.75	3.75	39,695	19.75A	2.62	6.78	20.05A	1.85	36.65	0.75	423.0	316.6
17	4.00	4.00	44,805	19.78A	2.76	6.56	19.93A	1.92	36.91	0.77	442.6	322.0
18	4.25	4.25	50,001	19.79A	2.90	6.41	19.82A	1.98	37.11	0.78	462.2	327.3
19	4.50	4.50	55,284	19.79A	3.05	6.32	19.72A	2.05	37.30	0.79	482.1	332.9
20	4.75	4.75	60,655	19.78A	3.19	6.26	19.63A	2.12	37.49	0.81	502.1	338.5
21	5.00	5.00	66,118	19.76A	3.32	6.24	19.53A	2.19	37.69	0.82	522.1	344.1
22	5.25	5.25	71,687	19.74A	3.46	6.36	19.52A	2.27	37.88	0.84	544.9	353.8
23	5.50	5.50	76,636	19.76A	3.59	4.01	33.05A	0.05	38.07	0.12	1,005.6	51.7

APPENDIX B

INTACT STABILITY CALCULATIONS

ETHAN ALLEN INVESTIGATION
DELIVERABLE 1: TASKS 1 - 5

LIGHTSHIP CALCULATION

deChamplain -- Inclining

Item	Weight	VCG	LCG	Note
Lightship	13585	5.25	-2.97	Inclining
Canopy	1780	10.82	-3.20	Scarano Canopy Report
Sub	11805	4.41	-2.94	
Ballast	1210	1.75	1.29	22 blocks x 55#
Sub	10595	4.71	-3.42	
Engine	1082	3.00	-4.80	Curtis
Hull	9513	4.91	-3.26	

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Item	Weight	VCG	LCG	Note
from Scale	15300	5.01	-2.51	
Fuel	-178.25	2.46	4.29	
Water fwd	-340	1.00	3.25	
Water ER	-42.5	1.00	-6.75	
Anchor	-20	6.00	16.00	
Hatch Cover	45	5.46	12.50	
Window	5	8.00	0.00	
Gear Head	-40	3.00	-14.26	
Gear Fwd	-40	6.00	16.00	
	14689	5.29	-2.71	
Ballast	1155	1.75	1.29	
Engine	1120	3.00	-4.80	
Canopy	1930	10.82	-3.20	
	10484	4.91	-2.84	

1964			
Hull	10484	4.91	-2.84
Ballast	1155	1.75	1.29
Engine	1120	3.00	-4.80
	12759	**4.46**	**-2.64**
1979 - Steel			
1964	12759	4.46	-2.64
Steel Canopy	1831	11.71	-3.20
	14590	**5.37**	**-2.71**
1979 - Al			
1964	12759	4.46	-2.64
Al Canopy	783	11.65	-3.20
	13542	**4.87**	**-2.67**
2005 - Wood			
1964	12759	4.46	-2.64
Wood Canopy	1930	10.82	-3.20
	14689	**5.29**	**-2.71**
2005 - deChamplain			
	13753	**5.36**	**-2.86**

deChamplain -- Freeboard

Item	Weight	VCG	LCG	Note
from Scale	14288	5.25	-2.5884	
Fuel	-535	2.46	4.29	
Lightship	13753	5.36	-2.86	
Canopy	1780	10.82	-3.20	Scarano Canopy Report
Sub	11973	4.55	-2.81	
Ballast	1210	1.75	1.29	22 blocks x 55#
Sub	10763	4.86	-3.27	
Engine	1082	3.00	-4.80	Curtis
Hull	9681	5.07	-3.09	

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Intact Trim and Stability Summary
EA - Freeboard

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	13,093	4.7800	2.5800A	0.0000	---	
Constant	0	0.0000	0.0000	0.0000	0.000	
Fuel Oil	0	---	---	---	---	
Misc. Weights	2,159	4.7800	2.0070A	0.0000	0.000	
Displacement	15,252	4.7800	2.4989A	0.0000	0.000	
Stability Calculation			**Trim Calculation**			
KMt	8.6339	ft	LCF Draft		2.4750	ft
VCG	4.7800	ft	LCB		2.5176A	ft-MS
GMt (Solid)	3.8539	ft	LCF		4.0557A	ft-MS
FSc	0.0000	ft	MT1in		1.31	ft-LT/in
GMt (Corrected)	3.8539	ft	Trim		0.1877	ft-A
			List		0	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.5462	ft				
Draft at M.S.	2.4523	ft				
Draft at F.P.	2.3585	ft				
Draft at Aft Marks	2.5497	ft				
Draft at Mid Marks	2.4523	ft				
Draft at Fwd Marks	2.3549	ft				

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Intact Trim and Stability Summary
dC - Freeboard

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	13,093	4.7800	2.5800A	0.0000	---	
Constant	0	0.0000	0.0000	0.0000	0.000	
Fuel Oil	0	---	---	---	---	
Misc. Weights	1,195	4.7800	2.6806A	0.0000	0.000	
Displacement	14,288	4.7800	2.5884A	0.0000	0.000	
Stability Calculation			**Trim Calculation**			
KMt	8.7468	ft	LCF Draft		2.4160	ft
VCG	4.7800	ft	LCB		2.6149A	ft-MS
GMt (Solid)	3.9668	ft	LCF		4.1544A	ft-MS
FSc	0.0000	ft	MT1in		1.27	ft-LT/in
GMt (Corrected)	3.9668	ft	Trim		0.2718	ft-A
			List		0	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.5182	ft				
Draft at M.S.	2.3824	ft				
Draft at F.P.	2.2465	ft				
Draft at Aft Marks	2.5234	ft				
Draft at Mid Marks	2.3824	ft				
Draft at Fwd Marks	2.2413	ft				

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Intact Trim and Stability Summary
dC - Truck Scale

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	13,093	4.7800	2.5800A	0.0000	---	
Constant	0	0.0000	0.0000	0.0000	0.000	
Fuel Oil	0	---	---	---	---	
Misc. Weights	1,757	4.7800	3.3385A	0.0000	0.000	
Displacement	14,850	4.7800	2.6697A	0.0000	0.000	
Stability Calculation			**Trim Calculation**			
KMt	8.6983	ft	LCF Draft		2.4509	ft
VCG	4.7800	ft	LCB		2.6970A	ft-MS
GMt (Solid)	3.9183	ft	LCF		4.1471A	ft-MS
FSc	0.0000	ft	MT1in		1.29	ft-LT/in
GMt (Corrected)	3.9183	ft	Trim		0.2818	ft-A
			List		0	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.5569	ft				
Draft at M.S.	2.4160	ft				
Draft at F.P.	2.2751	ft				
Draft at Aft Marks	2.5623	ft				
Draft at Mid Marks	2.4160	ft				
Draft at Fwd Marks	2.2697	ft				

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Intact Trim and Stability Summary
dC - Inclining

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	13,093	4.7800	2.5800A	0.0000	---	
Constant	0	0.0000	0.0000	0.0000	0.000	
Fuel Oil	0	---	---	---	---	
Misc. Weights	2,764	4.7800	0.3070A	0.0000	0.000	
Displacement	15,857	4.7800	2.1838A	0.0000	0.000	
Stability Calculation			**Trim Calculation**			
KMt	8.5337	ft	LCF Draft		2.5115	ft
VCG	4.7800	ft	LCB		2.1870A	ft-MS
GMt (Solid)	3.7537	ft	LCF		3.8970A	ft-MS
FSc	0.0000	ft	MT1in		1.34	ft-LT/in
GMt (Corrected)	3.7537	ft	Trim		0.0168	ft-A
			List		0	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.5179	ft				
Draft at M.S.	2.5095	ft				
Draft at F.P.	2.5011	ft				
Draft at Aft Marks	2.5182	ft				
Draft at Mid Marks	2.5095	ft				
Draft at Fwd Marks	2.5008	ft				

APPENDIX C

INTACT STABILITY CALCULATIONS

ETHAN ALLEN INVESTIGATION
DELIVERABLE 1: TASKS 1 - 5

SIMPLIFIED STABILITY TEST

ETHAN ALLEN
Stability Analysis

46 CFR - PART 178 - INTACT STABILITY AND SEAWORTHINESS
SUBPART C - Intact Stability Standards
§178.330 - Simplified stability proof test

Assumptions for are conditions:
Fuel tanks are 75% full. (75 gal, 535 lb.)
Minimum freeboard occurs at passenger threshold:
9.74' aft MS
5.98' off CL
5.47' aBL
Weight of passengers is 140# ea. for operation in protected waters.

(1) Total Test Weight Required		1964-SW-2.5	1964-SW-1.5	1979-Steel-SW	1979-Steel-FW	1979-Al-SW	1979-Al-FW	2005-FW
No. of Passengers		48	48	48	48	48	48	48
Weight/Passenger	lb/pass.	140	140	140	140	140	140	140
Total Test Weight	lb	6720	6720	6720	6720	6720	6720	6720
(2) Distribution of Test Weight								
<<Not Applicable. Main deck only.>>								
(3) Location of Mark for Maximum Allowable Immersion above UPRIGHT Load Waterline								
(a) Flush Deck Type Vessel								
(f) Ref. Freeboard	in	33.72	33.72	32.52	32.304	33.24	32.88	32.4
(h) Height of Mark = (f) / 2	in	16.86	16.86	16.26	16.152	16.62	16.44	16.2
(b) Cockpit Type Vessels - Not Applicable								
(c) Open-boat Type Vessels - Not Applicable								
(d) For All Types of Vessels								
Beam at Ref. Station	ft	11.78	11.78	11.78	11.78	11.78	11.78	11.78
(h) Height of Mark = B/8	in	17.67	17.67	17.67	17.67	17.67	17.67	17.67
(h) Minimum of (a) and (d)	in	16.86	16.86	16.26	16.152	16.62	16.44	16.2
(4) Required Heeling Moment								
(a) Passenger Heeling Moment								
Bp = Max. B accessible	ft	10	10	10	10	10	10	10
Total Test Weight	lb	6720	6720	6720	6720	6720	6720	6720
Pass. Mom = Bp*W/6	ft-lb	11200	11200	11200	11200	11200	11200	11200
(b) Wind Heeling Moment								
Area	ft2	164.9	164.9	379.4	378.3	381.5	380.4	334.9
H (Center from WL)	ft	2.26	2.26	5.18	5.16	5.21	5.19	4.55
A*H	ft3	372.4	372.4	1964.5	1953.1	1987.4	1975.9	1522.8
P (protected waters)	lb/ft2	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Mw = A*H * P	ft-lb	2793	2793	14734	14648	14905	14819	11421
Apply greater of Mw and Mp	ft-lb	11200	11200	14734	14648	14905	14819	11421
(5) Weight Movement								
Heeling Moment	ft-lb	11200	11200	14734	14648	14905	14819	11421
Total Test Weight	lb	6720	6720	6720	6720	6720	6720	6720
Arm	ft	1.67	1.67	2.19	2.18	2.22	2.21	1.70
(6) Height of Ref. Mark after Weight Movement								
Minimum FB	ft	0.24	1.38	1.18	1.11	0.97	0.82	1.05
Height to Mark	in	-13.98	-0.3	-2.1	-2.832	-4.98	-6.6	-3.6
Result		FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
(if capsize - max arm upright)		1.62		1.07	1.06	1.34	1.34	1.12

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Intact Trim and Stability Summary
1964-Simp

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	6,720	7.96	0.25F	1.62S	0	
Displacement	20,014	5.58	1.56A	0.54S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.14	ft	LCF Draft		2.18	ft
VCG	5.58	ft	LCB		1.45A	ft-MS
GMt (Solid)	2.57	ft	LCF		1.97A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.56	ft	Trim		1.26	ft-F
			List		28.9S	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	1.62	ft				
Draft at M.S.	2.25	ft				
Draft at F.P.	2.88	ft				
Draft at Aft Marks	1.60	ft				
Draft at Mid Marks	2.25	ft				
Draft at Fwd Marks	2.90	ft				

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Tankage and Cargo Summary
1964-Simp

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	6,720	7.96	0.25F	1.62S	0	16.40A	16.40F
Totals	6,720	7.96	0.25F	1.62S	0		

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Freeboards
1964-Simp

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	4.54
2	ER VENT P	6.13A	2.70P	6.00	4.78
3	ER VENT S	6.13A	3.50S	6.00	1.79
4	Min	9.74A	5.98S	5.47	0.24
5	Min	9.74A	5.98P	5.47	6.02

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Intact Trim and Stability Summary
1964-Simp-1.5 VCG

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	6,720	6.96	0.25F	1.67S	0	
Displacement	20,014	5.24	1.56A	0.56S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.14	ft	LCF Draft		2.59	ft
VCG	5.24	ft	LCB		1.51A	ft-MS
GMt (Solid)	2.90	ft	LCF		2.64A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.90	ft	Trim		0.68	ft-F
			List		14.9S	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.31	ft				
Draft at M.S.	2.65	ft				
Draft at F.P.	2.99	ft				
Draft at Aft Marks	2.29	ft				
Draft at Mid Marks	2.65	ft				
Draft at Fwd Marks	3.00	ft				

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Tankage and Cargo Summary
1964-Simp-1.5 VCG

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	6,720	6.96	0.25F	1.67S	0	16.40A	16.40F
Totals	6,720	6.96	0.25F	1.67S	0		

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Freeboards
1964-Simp-1.5 VCG

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.91
2	ER VENT P	6.13A	2.70P	6.00	4.05
3	ER VENT S	6.13A	3.50S	6.00	2.46
4	Min	9.74A	5.98S	5.47	1.38
5	Min	9.74A	5.98P	5.47	4.45

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Intact Trim and Stability Summary
1979-Steel-SW-Simp

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,551	8.76	0.49A	0.84S	0	
Displacement	21,845	6.09	1.70A	0.33S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.01	ft	LCF Draft		2.69	ft
VCG	6.09	ft	LCB		1.63A	ft-MS
GMt (Solid)	1.92	ft	LCF		2.61A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	1.92	ft	Trim		0.70	ft-F
			List		15.9S	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.40	ft				
Draft at M.S.	2.75	ft				
Draft at F.P.	3.09	ft				
Draft at Aft Marks	2.38	ft				
Draft at Mid Marks	2.75	ft				
Draft at Fwd Marks	3.11	ft				

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Tankage and Cargo Summary
1979-Steel-SW-Simp

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,720	7.96	0.25F	1.07S	0	16.40A	16.40F
Totals	8,551	8.76	0.49A	0.84S	0		

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Freeboards
1979-Steel-SW-Simp

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.84
2	ER VENT P	6.13A	2.70P	6.00	3.99
3	ER VENT S	6.13A	3.50S	6.00	2.29
4	Min	9.74A	5.98S	5.47	1.18
5	Min	9.74A	5.98P	5.47	4.45

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Intact Trim and Stability Summary
1979-Steel-FW-Simp

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,551	8.76	0.49A	0.83S	0	
Displacement	21,845	6.09	1.70A	0.33S	0	
Stability Calculation			**Trim Calculation**			
KMt	7.97	ft	LCF Draft		2.72	ft
VCG	6.09	ft	LCB		1.62A	ft-MS
GMt (Solid)	1.88	ft	LCF		2.58A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	1.87	ft	Trim		0.72	ft-F
			List		16.3S	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.41	ft				
Draft at M.S.	2.77	ft				
Draft at F.P.	3.14	ft				
Draft at Aft Marks	2.40	ft				
Draft at Mid Marks	2.77	ft				
Draft at Fwd Marks	3.15	ft				

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Tankage and Cargo Summary
1979-Steel-FW-Simp

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,720	7.96	0.25F	1.06S	0	16.15A	16.65F
Totals	8,551	8.76	0.49A	0.83S	0		

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Freeboards
1979-Steel-FW-Simp

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.83
2	ER VENT P	6.13A	2.70P	6.00	3.98
3	ER VENT S	6.13A	3.50S	6.00	2.24
4	Min	9.74A	5.98S	5.47	1.11
5	Min	9.74A	5.98P	5.47	4.47

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Intact Trim and Stability Summary
1979-Al-SW-Simp

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	7,503	8.35	0.11A	1.20S	0	
Displacement	20,797	5.81	1.63A	0.43S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.09	ft	LCF Draft		2.55	ft
VCG	5.81	ft	LCB		1.56A	ft-MS
GMt (Solid)	2.28	ft	LCF		2.41A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.28	ft	Trim		0.81	ft-F
			List		19.0S	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.21	ft				
Draft at M.S.	2.61	ft				
Draft at F.P.	3.02	ft				
Draft at Aft Marks	2.19	ft				
Draft at Mid Marks	2.61	ft				
Draft at Fwd Marks	3.03	ft				

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Tankage and Cargo Summary
1979-Al-SW-Simp

Fuel Oil

	Weight	%	Capacity	VCG	LCG	TCG	FSmom	Density	Volume		API	Temp
	lbs	Full	lbs	ft-BL	ft-MS	ft-CL	ft-LT	lb/ft3	gal	bbls	Gravity	deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight	VCG	LCG	TCG	FSmom	Aft Bound	Fwd Bound
	lbs	ft-BL	ft-MS	ft-CL	ft-LT	ft-MS	ft-MS
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,720	7.96	0.25F	1.34S	0	16.70A	16.10F
Totals	7,503	8.35	0.11A	1.20S	0		

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Freeboards
1979-Al-SW-Simp

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	4.05
2	ER VENT P	6.13A	2.70P	6.00	4.22
3	ER VENT S	6.13A	3.50S	6.00	2.20
4	Min	9.74A	5.98S	5.47	0.97
5	Min	9.74A	5.98P	5.47	4.87

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Intact Trim and Stability Summary
1979-Al-FW-Simp

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	7,503	8.35	0.11A	1.20S	0	
Displacement	20,797	5.81	1.63A	0.43S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.05	ft	LCF Draft		2.55	ft
VCG	5.81	ft	LCB		1.54A	ft-MS
GMt (Solid)	2.24	ft	LCF		2.32A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.24	ft	Trim		0.88	ft-F
			List		20.5S	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.17	ft				
Draft at M.S.	2.61	ft				
Draft at F.P.	3.05	ft				
Draft at Aft Marks	2.16	ft				
Draft at Mid Marks	2.61	ft				
Draft at Fwd Marks	3.07	ft				

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Tankage and Cargo Summary
1979-Al-FW-Simp

Fuel Oil

	Weight	%	Capacity	VCG	LCG	TCG	FSmom	Density	Volume		API	Temp
	lbs	Full	lbs	ft-BL	ft-MS	ft-CL	ft-LT	lb/ft3	gal	bbls	Gravity	deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight	VCG	LCG	TCG	FSmom	Aft Bound	Fwd Bound
	lbs	ft-BL	ft-MS	ft-CL	ft-LT	ft-MS	ft-MS
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,720	7.96	0.25F	1.34S	0	16.70A	16.10F
Totals	7,503	8.35	0.11A	1.20S	0		

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Freeboards
1979-Al-FW-Simp

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	4.08
2	ER VENT P	6.13A	2.70P	6.00	4.27
3	ER VENT S	6.13A	3.50S	6.00	2.09
4	Min	9.74A	5.98S	5.47	0.82
5	Min	9.74A	5.98P	5.47	5.01

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Intact Trim and Stability Summary
2005-Simp

Item	Weight lbs		VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759		4.46	2.64A	0.00	----	
Constant	0		0.00	0.00	0.00	0	
Fuel Oil	535		2.26	1.29F	0.00	0	
Misc. Weights	8,650		8.60	0.52A	0.87S	0	
Displacement	21,944		6.04	1.71A	0.34S	0	
Stability Calculation				**Trim Calculation**			
KMt	7.96	ft		LCF Draft		2.71	ft
VCG	6.04	ft		LCB		1.63A	ft-MS
GMt (Solid)	1.92	ft		LCF		2.55A	ft-MS
FSc	0.00	ft		MT1in		1	ft-LT/in
GMt (Corrected)	1.92	ft		Trim		0.74	ft-F
				List		16.9S	deg
Specific Gravity	1.000						
Hull calcs from offsets				Tank calcs from tables			
Drafts							
Draft at A.P.	2.40	ft					
Draft at M.S.	2.77	ft					
Draft at F.P.	3.14	ft					
Draft at Aft Marks	2.38	ft					
Draft at Mid Marks	2.77	ft					
Draft at Fwd Marks	3.15	ft					

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Tankage and Cargo Summary
2005-Simp

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
WOOD CANOPY	1,930	10.82	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,720	7.96	0.25F	1.12S	0	16.70A	16.10F
Totals	8,650	8.60	0.52A	0.87S	0		

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Freeboards
2005-Simp

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.85
2	ER VENT P	6.13A	2.70P	6.00	4.01
3	ER VENT S	6.13A	3.50S	6.00	2.20
4	Min	9.74A	5.98S	5.47	1.05
5	Min	9.74A	5.98P	5.47	4.53

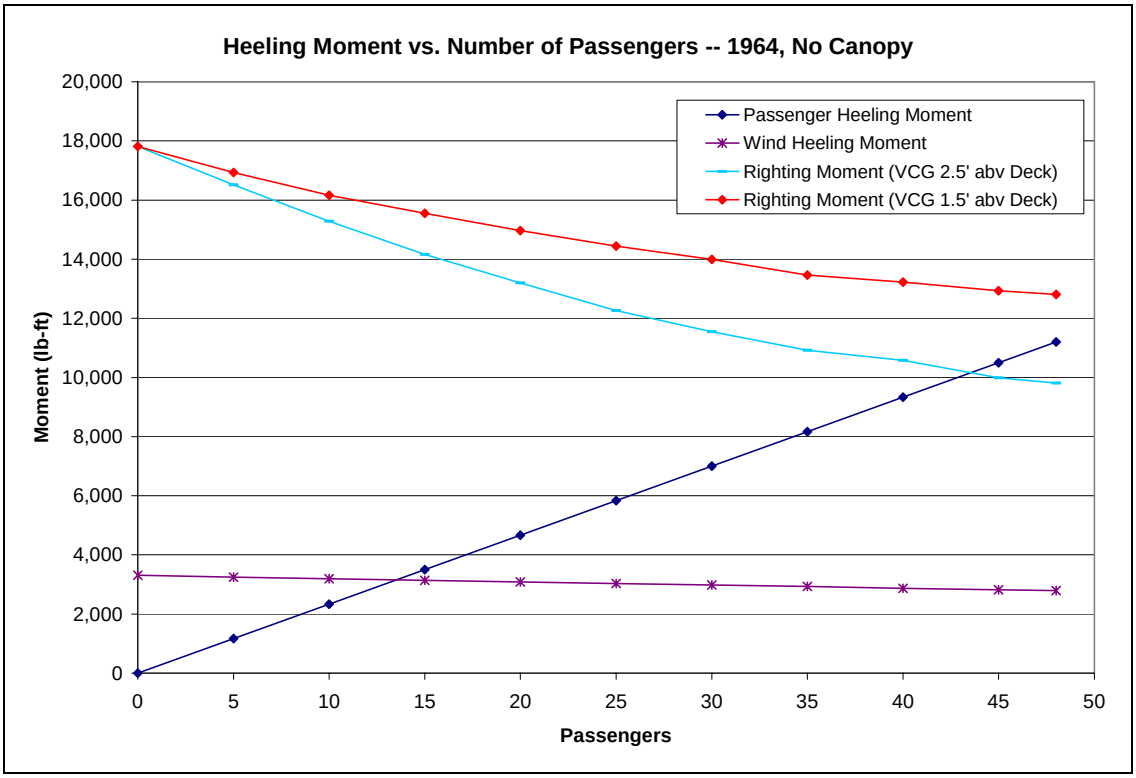
ETHAN ALLEN
Stability Analysis

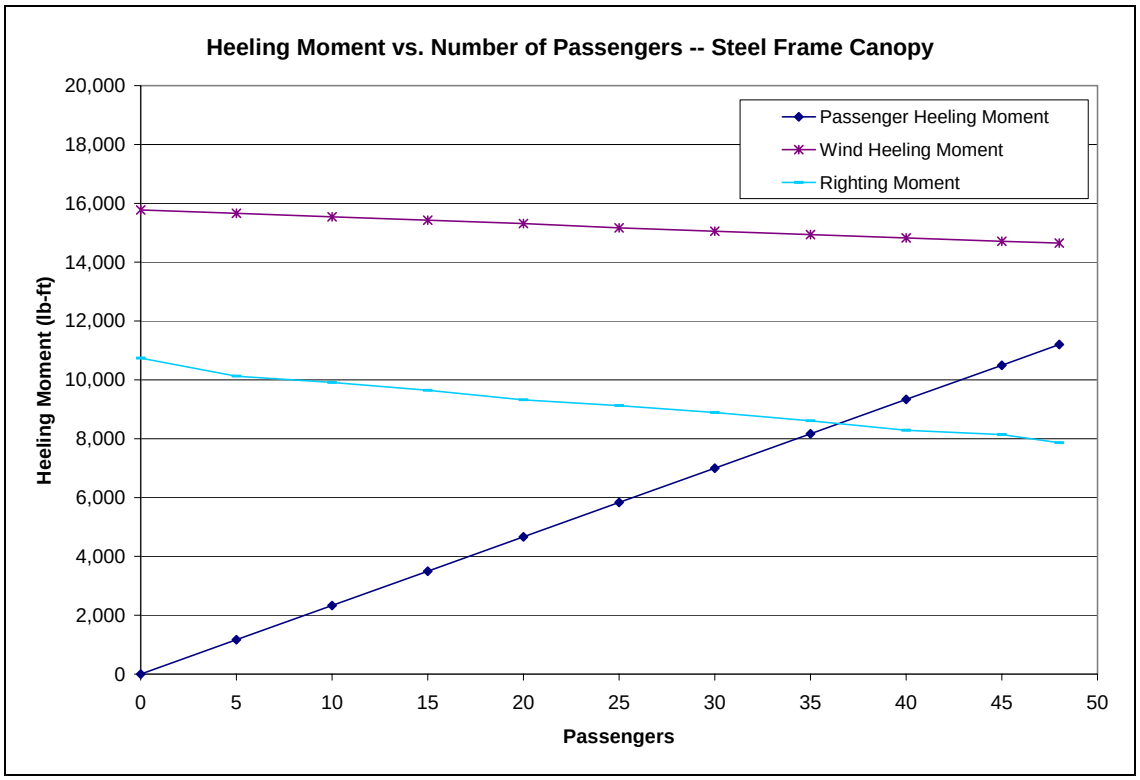
46 CFR - PART 178 - INTACT STABILITY AND SEAWORTHINESS
SUBPART C - Intact Stability Standards
§178.330 - Simplified stability proof test

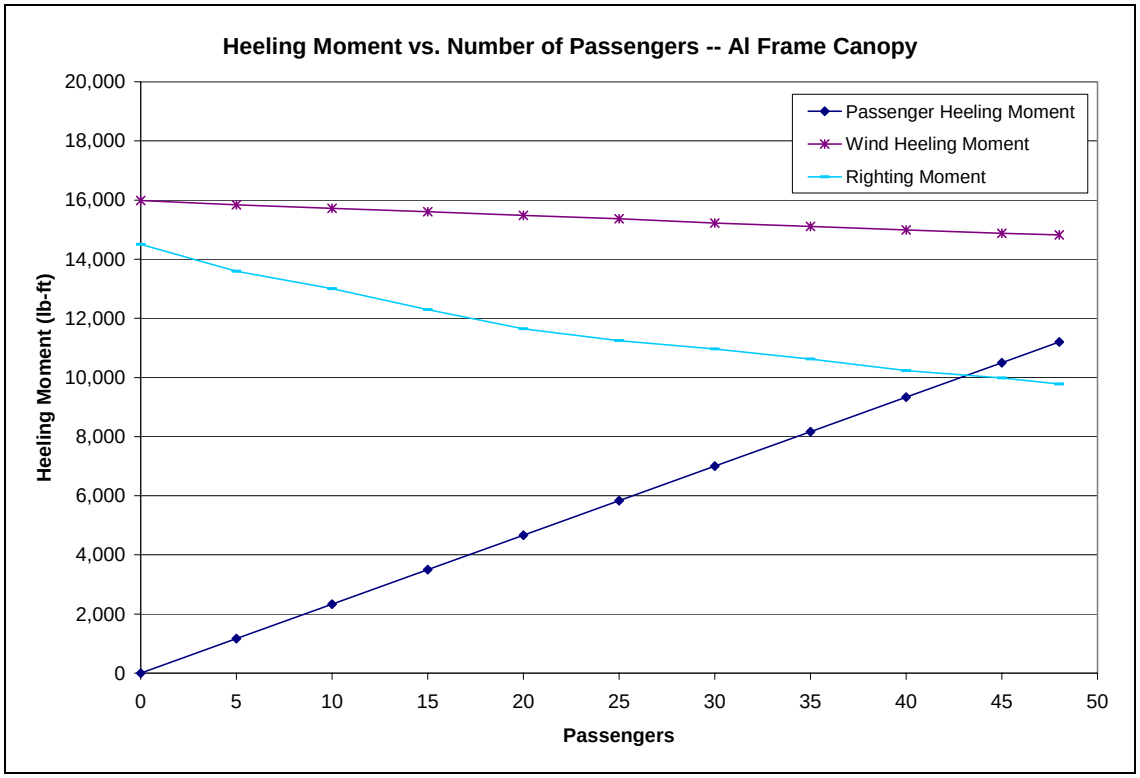
Assumptions for all conditions:
Fuel tanks are 75% full. (75 gal, 535 lb.)
Minimum freeboard occurs at passenger threshold:
9.74' aft MS
5.98' off CL
5.47' aBL
Weight of passengers is 140# ea. for operation in protected waters.

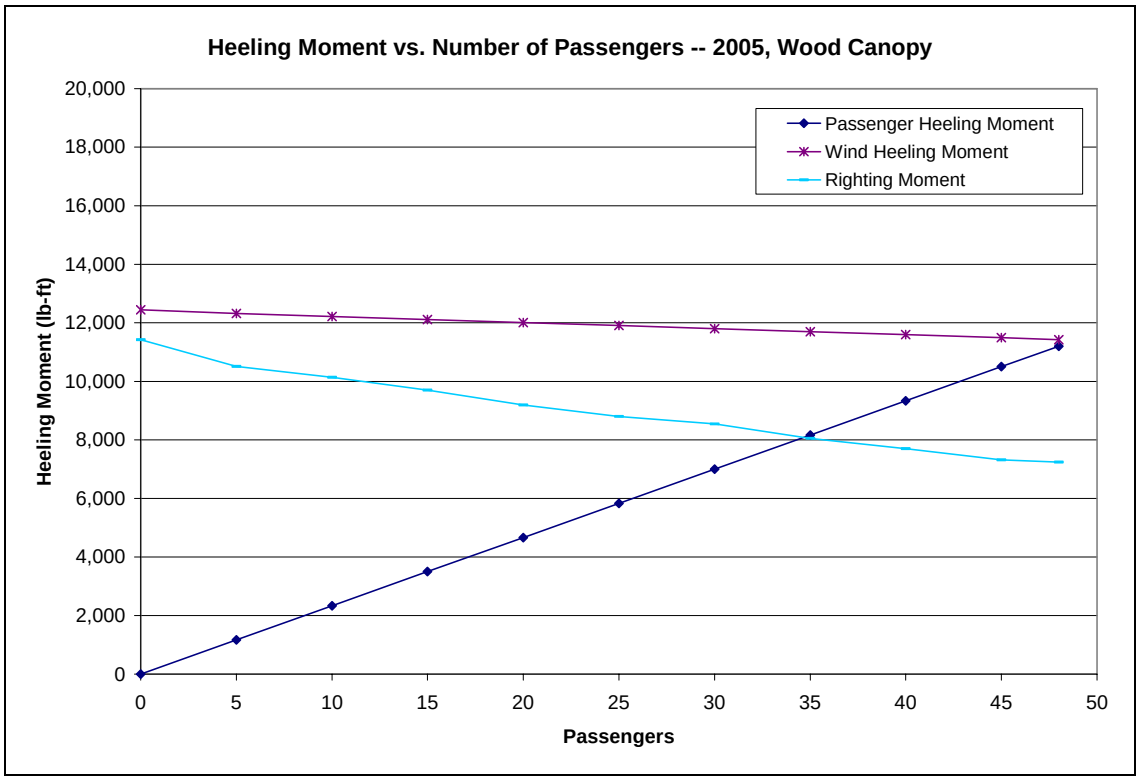
		1964-SW-2.5	1964-SW-1.5	1979-Steel-SW	1979-Steel-FW	1979-Al-SW	1979-Al-FW	2005-FW
(1) Total Test Weight Required								
No. of Passengers		41	47	28	27	27	27	22
Weight/Passenger	lb/pass.	140	140	140	140	140	140	140
Total Test Weight	lb	5740	6580	3920	3780	3780	3780	3080
(2) Distribution of Test Weight								
<<Not Applicable. Main deck only.>>								
(3) Location of Mark for Maximum Allowable Immersion above UPRIGHT Load Waterline								
(a) Flush Deck Type Vessel								
(f) Ref. Freeboard	in	34.32	33.96	33.96	33.84	34.8	34.44	34.08
(h) Height of Mark = (f) / 2	in	17.16	16.98	16.98	16.92	17.4	17.22	17.04
(b) Cockpit Type Vessels - Not Applicable								
(c) Open-boat Type Vessels - Not Applicable								
(d) For All Types of Vessels								
Beam at Ref. Station	ft	11.96	11.96	11.96	11.96	11.96	11.96	11.96
(h) Height of Mark = B/8	in	17.94	17.94	17.94	17.94	17.94	17.94	17.94
(h) Minimum of (a) and (d)	in	17.16	16.98	16.98	16.92	17.4	17.22	17.04
(4) Required Heeling Moment								
(a) Passenger Heeling Moment								
Bp = Max. B accessible	ft	10	10	10	10	10	10	10
Total Test Weight	lb	5740	6580	3920	3780	3780	3780	3080
Pass. Mom = Bp*W/6	ft-lb	9567	10967	6533	6300	6300	6300	5133
(b) Wind Heeling Moment								
Draft	ft	2.67	2.72	2.67	2.69	2.61	2.63	2.66
Area	ft2	167.1	165.3	385.1	384.4	387.3	386.6	342.4
H (Center from WL)	ft	2.29	2.26	5.26	5.25	5.29	5.28	4.66
A*H	ft3	382.4	374.1	2025.8	2018.1	2049.0	2041.3	1594.1
P (protected waters)	lb/ft2	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Mw = A*H * P	ft-lb	2868	2805	15194	15136	15368	15310	11956
Apply greater of Mw and Mp	ft-lb	9567	10967	15194	15136	15368	15310	11956
(5) Weight Movement								
Heeling Moment	ft-lb	9567	10967	15194	15136	15368	15310	11956
Total Test Weight	lb	5740	6580	3920	3780	3780	3780	3080
Arm	ft	1.67	1.67	3.88	4.00	4.07	4.05	3.88
(6) Height of Ref. Mark after Weight Movement								
Minimum FB	ft	1.49	1.44					
Height to Mark	in	0.72	0.3	FAIL	FAIL	FAIL	FAIL	FAIL
Result		PASS	PASS					

Calculation shown with passenger load corresponding to realistic weight movement.


Heeling Moment vs. Number of Passengers -- 1964, No Canopy
Passenger Heeling Moment
Wind Heeling Moment
Righting Moment (VCG 2.5' abv Deck)
Righting Moment (VCG 1.5' abv Deck)
Moment (lb-ft)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
5
10
15
20
25
30
35
40
45
50
Passengers


Heeling Moment vs. Number of Passengers -- Steel Frame Canopy
Passenger Heeling Moment
Wind Heeling Moment
Righting Moment
Heeling Moment (lb-ft)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
5
10
15
20
25
30
35
40
45
50
Passengers


Heeling Moment vs. Number of Passengers -- Al Frame Canopy
Passenger Heeling Moment
Wind Heeling Moment
Righting Moment
Heeling Moment (lb-ft)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
5
10
15
20
25
30
35
40
45
50
Passengers


Heeling Moment vs. Number of Passengers -- 2005, Wood Canopy
Passenger Heeling Moment
Wind Heeling Moment
Righting Moment
Heeling Moment (lb-ft)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
5
10
15
20
25
30
35
40
45
50
Passengers

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Intact Trim and Stability Summary
1964-Simp-Pass

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	5,740	7.96	0.25F	1.67S	0	
Displacement	19,034	5.45	1.66A	0.50S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.23	ft	LCF Draft		2.54	ft
VCG	5.45	ft	LCB		1.60A	ft-MS
GMt (Solid)	2.78	ft	LCF		2.73A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.78	ft	Trim		0.58	ft-F
			List		14.2S	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.30	ft				
Draft at M.S.	2.59	ft				
Draft at F.P.	2.88	ft				
Draft at Aft Marks	2.29	ft				
Draft at Mid Marks	2.59	ft				
Draft at Fwd Marks	2.89	ft				

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Tankage and Cargo Summary
1964-Simp-Pass

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	5,740	7.96	0.25F	1.67S	0	16.40A	16.40F
Totals	5,740	7.96	0.25F	1.67S	0		

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Freeboards
1964-Simp-Pass

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.94
2	ER VENT P	6.13A	2.70P	6.00	4.07
3	ER VENT S	6.13A	3.50S	6.00	2.55
4	Min	9.74A	5.98S	5.47	1.49
5	Min	9.74A	5.98P	5.47	4.42

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Intact Trim and Stability Summary
1964-Simp-Pass-1.5 VCG

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	6,580	6.96	0.25F	1.67S	0	
Displacement	19,874	5.23	1.58A	0.55S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.16	ft	LCF Draft		2.60	ft
VCG	5.23	ft	LCB		1.52A	ft-MS
GMt (Solid)	2.93	ft	LCF		2.68A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.92	ft	Trim		0.66	ft-F
			List		14.3S	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.32	ft				
Draft at M.S.	2.65	ft				
Draft at F.P.	2.98	ft				
Draft at Aft Marks	2.31	ft				
Draft at Mid Marks	2.65	ft				
Draft at Fwd Marks	2.99	ft				

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Tankage and Cargo Summary
1964-Simp-Pass-1.5 VCG

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	6,580	6.96	0.25F	1.67S	0	16.40A	16.40F
Totals	6,580	6.96	0.25F	1.67S	0		

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Freeboards
1964-Simp-Pass-1.5 VCG

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.89
2	ER VENT P	6.13A	2.70P	6.00	4.03
3	ER VENT S	6.13A	3.50S	6.00	2.50
4	Min	9.74A	5.98S	5.47	1.44
5	Min	9.74A	5.98P	5.47	4.39

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Intact Trim and Stability Summary
1979-Steel-SW-Simp-Pass

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	5,751	9.15	0.85A	2.64S	0	
Displacement	19,045	5.82	1.99A	0.80S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.27	ft	LCF Draft		-9.19	ft
VCG	5.82	ft	LCB		1.97A	ft-MS
GMt (Solid)	2.45	ft	LCF		3.67A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.45	ft	Trim		14.63	ft-F
			List		*NA*	
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	-14.90	ft				
Draft at M.S.	-7.59	ft				
Draft at F.P.	-0.27	ft				
Draft at Aft Marks	-15.18	ft				
Draft at Mid Marks	-7.59	ft				
Draft at Fwd Marks	0.01	ft				

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Tankage and Cargo Summary
1979-Steel-SW-Simp-Pass

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	3,920	7.96	0.25F	3.88S	0	16.40A	16.40F
Totals	5,751	9.15	0.85A	2.64S	0		

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HECSALV 7.6.6beta

Freeboards
1979-Steel-SW-Simp-Pass

Equilibrium not found within range of angles selected

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	11.90
2	ER VENT P	6.13A	2.70P	6.00	14.91
3	ER VENT S	6.13A	3.50S	6.00	14.91
4	Min	9.74A	5.98S	5.47	15.87
5	Min	9.74A	5.98P	5.47	15.87

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Intact Trim and Stability Summary
1979-Steel-FW-Simp-Pass

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	5,611	9.18	0.88A	2.69S	0	
Displacement	18,905	5.80	2.01A	0.80S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.24	ft	LCF Draft		-8.96	ft
VCG	5.80	ft	LCB		1.98A	ft-MS
GMt (Solid)	2.44	ft	LCF		3.66A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.44	ft	Trim		14.45	ft-F
			List		*NA*	
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	-14.61	ft				
Draft at M.S.	-7.38	ft				
Draft at F.P.	-0.16	ft				
Draft at Aft Marks	-14.88	ft				
Draft at Mid Marks	-7.38	ft				
Draft at Fwd Marks	0.12	ft				

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Tankage and Cargo Summary
1979-Steel-FW-Simp-Pass

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	3,780	7.96	0.25F	4.00S	0	16.40A	16.40F
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
Totals	5,611	9.18	0.88A	2.69S	0		

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Freeboards
1979-Steel-FW-Simp-Pass

Equilibrium not found within range of angles selected

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	11.75
2	ER VENT P	6.13A	2.70P	6.00	14.72
3	ER VENT S	6.13A	3.50S	6.00	14.72
4	Min	9.74A	5.98S	5.47	15.66
5	Min	9.74A	5.98P	5.47	15.66

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Intact Trim and Stability Summary
1979-Al-SW-Simp-Pass

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	4,563	8.59	0.34A	3.37S	0	
Displacement	17,857	5.45	1.94A	0.86S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.37	ft	LCF Draft		-10.02	ft
VCG	5.45	ft	LCB		1.92A	ft-MS
GMt (Solid)	2.92	ft	LCF		3.71A	ft-MS
FSc	0.01	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.91	ft	Trim		15.17	ft-F
			List		*NA*	
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	-15.93	ft				
Draft at M.S.	-8.34	ft				
Draft at F.P.	-0.75	ft				
Draft at Aft Marks	-16.22	ft				
Draft at Mid Marks	-8.34	ft				
Draft at Fwd Marks	-0.46	ft				

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Tankage and Cargo Summary
1979-Al-SW-Simp-Pass

Fuel Oil

	Weight	%	Capacity	VCG	LCG	TCG	FSmom	Density	Volume		API	Temp
	lbs	Full	lbs	ft-BL	ft-MS	ft-CL	ft-LT	lb/ft3	gal	bbls	Gravity	deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight	VCG	LCG	TCG	FSmom	Aft Bound	Fwd Bound
	lbs	ft-BL	ft-MS	ft-CL	ft-LT	ft-MS	ft-MS
PASSENGERS	3,780	7.96	0.25F	4.07S	0	16.40A	16.40F
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
Totals	4,563	8.59	0.34A	3.37S	0		

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Freeboards
1979-Al-SW-Simp-Pass

Equilibrium not found within range of angles selected

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	12.50
2	ER VENT P	6.13A	2.70P	6.00	15.59
3	ER VENT S	6.13A	3.50S	6.00	15.59
4	Min	9.74A	5.98S	5.47	16.60
5	Min	9.74A	5.98P	5.47	16.60

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Intact Trim and Stability Summary
1979-Al-FW-Simp-Pass

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	4,563	8.59	0.34A	3.36S	0	
Displacement	17,857	5.45	1.94A	0.86S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.33	ft	LCF Draft		-9.71	ft
VCG	5.45	ft	LCB		1.92A	ft-MS
GMt (Solid)	2.88	ft	LCF		3.69A	ft-MS
FSc	0.01	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.87	ft	Trim		15.05	ft-F
			List		*NA*	
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	-15.58	ft				
Draft at M.S.	-8.05	ft				
Draft at F.P.	-0.52	ft				
Draft at Aft Marks	-15.86	ft				
Draft at Mid Marks	-8.05	ft				
Draft at Fwd Marks	-0.24	ft				

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Tankage and Cargo Summary
1979-Al-FW-Simp-Pass

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	3,780	7.96	0.25F	4.05S	0	16.40A	16.40F
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
Totals	4,563	8.59	0.34A	3.36S	0		

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Freeboards
1979-Al-FW-Simp-Pass

Equilibrium not found within range of angles selected

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	12.26
2	ER VENT P	6.13A	2.70P	6.00	15.33
3	ER VENT S	6.13A	3.50S	6.00	15.33
4	Min	9.74A	5.98S	5.47	16.32
5	Min	9.74A	5.98P	5.47	16.32

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Intact Trim and Stability Summary
2005-Simp-Pass

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.26	1.29F	0.00	0	
Misc. Weights	5,010	9.06	1.08A	2.39S	0	
Displacement	18,304	5.66	2.10A	0.65S	0	
Stability Calculation			**Trim Calculation**			
KMt	8.31	ft	LCF Draft		-9.36	ft
VCG	5.66	ft	LCB		2.08A	ft-MS
GMt (Solid)	2.65	ft	LCF		3.72A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.65	ft	Trim		14.26	ft-F
			List		*NA*	
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	-14.91	ft				
Draft at M.S.	-7.78	ft				
Draft at F.P.	-0.65	ft				
Draft at Aft Marks	-15.18	ft				
Draft at Mid Marks	-7.78	ft				
Draft at Fwd Marks	-0.38	ft				

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Tankage and Cargo Summary
2005-Simp-Pass

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
WOOD CANOPY	1,930	10.82	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	3,080	7.96	0.25F	3.88S	0	16.40A	16.40F
Totals	5,010	9.06	1.08A	2.39S	0		

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Freeboards
2005-Simp-Pass

Equilibrium not found within range of angles selected

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	12.14
2	ER VENT P	6.13A	2.70P	6.00	15.08
3	ER VENT S	6.13A	3.50S	6.00	15.08
4	Min	9.74A	5.98S	5.47	16.01
5	Min	9.74A	5.98P	5.47	16.01

APPENDIX D

INTACT STABILITY CALCULATIONS

ETHAN ALLEN INVESTIGATION
DELIVERABLE 1: TASKS 1 - 5

SUBCHAPTER S STABILITY CALCULATIONS

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Intact Trim and Stability Summary
1964

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	6,720	7.21	0.25F	0.08P	0	
Displacement	20,014	5.32	1.56A	0.03P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.14	ft	LCF Draft		2.73	ft
VCG	5.32	ft	LCB		1.52A	ft-MS
GMt (Solid)	2.82	ft	LCF		3.46A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.81	ft	Trim		0.47	ft-F
			List		0.5P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.54	ft				
Draft at M.S.	2.78	ft				
Draft at F.P.	3.01	ft				
Draft at Aft Marks	2.54	ft				
Draft at Mid Marks	2.78	ft				
Draft at Fwd Marks	3.02	ft				

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Tankage and Cargo Summary
1964

Fuel Oil

	Weight	%	Capacity	VCG	LCG	TCG	FSmom	Density	Volume		API	Temp
	lbs	Full	lbs	ft-BL	ft-MS	ft-CL	ft-LT	lb/ft3	gal	bbls	Gravity	deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight	VCG	LCG	TCG	FSmom	Aft Bound	Fwd Bound
	lbs	ft-BL	ft-MS	ft-CL	ft-LT	ft-MS	ft-MS
PASSENGERS	6,720	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	6,720	7.21	0.25F	0.08P	0		

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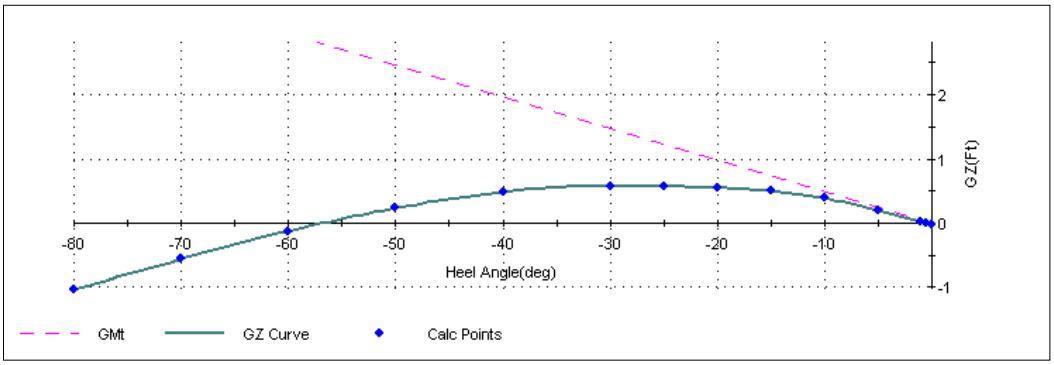
Righting Arm Summary
1964

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.5P
Angle at Maximum GZ	**deg**	29.4P
Area to 29.4 deg	**ft-deg**	12.54
Maximum GZ	**ft**	0.58
Range of Positive GZ	**deg**	56.3

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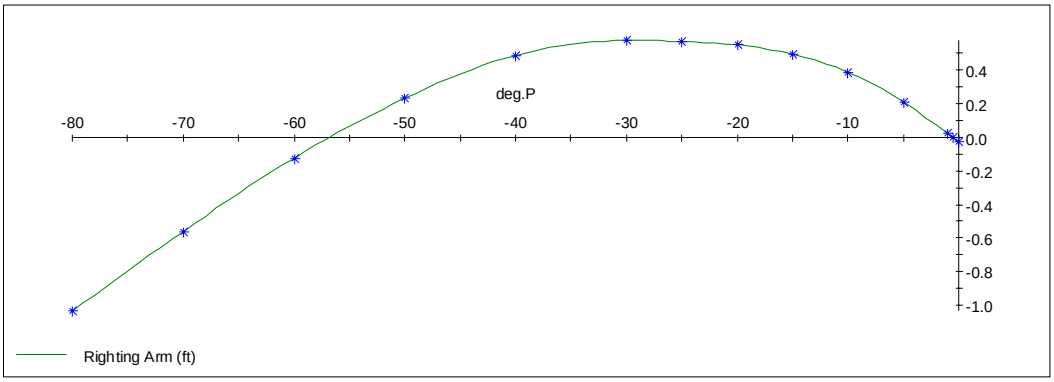
Draft/GZ Summary
1964



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.03	2.54	3.01	0	0.1	0.00F	3
0.5P	0.00	2.54	3.01	0	2.8	0.00F	1
1.0P	0.02	2.54	3.01	0	0.1	0.00F	3
5.0P	0.21	2.52	3.01	0	0.1	0.00F	3
10.0P	0.39	2.44	3.00	0	0.0	0.00F	3
15.0P	0.50	2.30	2.99	0	-0.3	0.00F	3
20.0P	0.55	2.11	2.97	0	-0.8	0.01F	3
25.0P	0.57	1.86	2.92	0	-1.5	0.01F	3
30.0P	0.58	1.56	2.86	0	-2.8	0.01F	3
40.0P	0.49	0.75	2.70	0	0.0	0.00F	4
50.0P	0.23	-0.38	2.56	0	-0.1	0.00F	4
60.0P	-0.12	-2.11	2.41	0	0.0	0.00F	4
70.0P	-0.56	-5.49	2.19	0	-0.3	0.00F	5
80.0P	-1.03	-15.24	1.31	0	-9.1	0.00F	9

Disp. of Remaining Intact Hull 20,014 lbs

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Freeboards
1964

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.18
2	ER VENT P	6.13A	2.70P	6.00	3.28
3	ER VENT S	6.13A	3.50S	6.00	3.34
4	Min	9.74A	5.98S	5.47	2.88
5	Min	9.74A	5.98P	5.47	2.77

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Intact Trim and Stability Summary
1979-Steel-SW

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,551	8.17	0.49A	0.06P	0	
Displacement	21,845	5.86	1.70A	0.02P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.01	ft	LCF Draft		2.83	ft
VCG	5.86	ft	LCB		1.65A	ft-MS
GMt (Solid)	2.15	ft	LCF		3.43A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.15	ft	Trim		0.49	ft-F
			List		0.7P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.64	ft				
Draft at M.S.	2.88	ft				
Draft at F.P.	3.12	ft				
Draft at Aft Marks	2.63	ft				
Draft at Mid Marks	2.88	ft				
Draft at Fwd Marks	3.13	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1979-Steel-SW

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	6,720	7.21	0.25F	0.08P	0	16.40A	16.40F
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
Totals	8,551	8.17	0.49A	0.06P	0		

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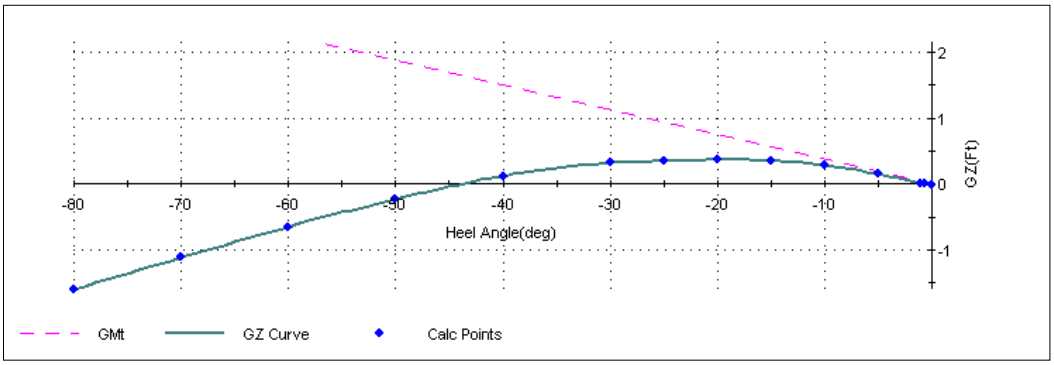
Righting Arm Summary
1979-Steel-SW

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.7P
Angle at Maximum GZ	**deg**	19.2P
Area to 19.2 deg	**ft-deg**	4.89
Maximum GZ	**ft**	0.37
Range of Positive GZ	**deg**	43.2

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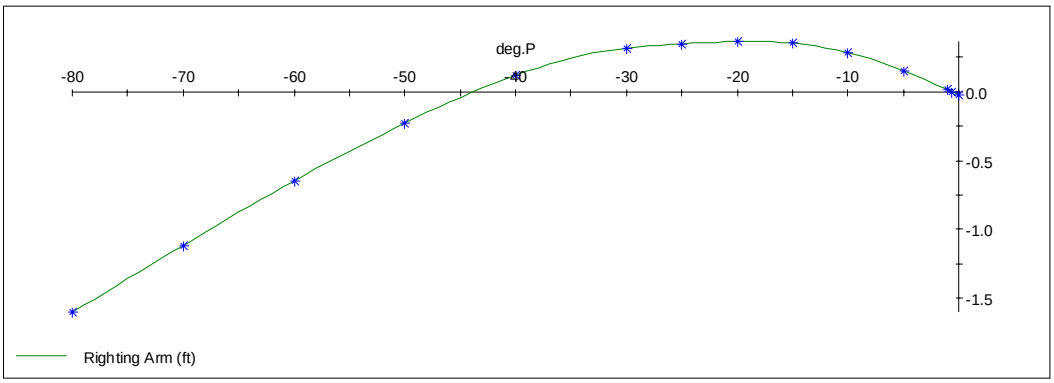
Draft/GZ Summary
1979-Steel-SW



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.02	2.64	3.13	0	0.2	0.00F	3
0.7P	0.00	2.64	3.12	0	2.4	0.00F	1
1.0P	0.01	2.64	3.12	0	0.2	0.00F	3
5.0P	0.15	2.62	3.11	0	0.0	0.01F	2
10.0P	0.29	2.55	3.11	0	0.1	0.00F	3
15.0P	0.35	2.43	3.09	0	-0.1	0.00F	3
20.0P	0.37	2.25	3.07	0	-0.5	0.01F	3
25.0P	0.35	2.01	3.03	0	0.1	0.00F	4
30.0P	0.32	1.72	2.97	0	0.0	0.00F	4
40.0P	0.12	0.96	2.83	0	0.1	0.00F	4
50.0P	-0.23	-0.08	2.71	0	0.0	0.00F	4
60.0P	-0.65	-1.64	2.58	0	0.2	0.01F	4
70.0P	-1.12	-4.70	2.42	0	-0.2	0.00F	5
80.0P	-1.60	-13.55	1.82	0	0.0	0.00F	9

Disp. of Remaining Intact Hull 21,845 lbs

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Freeboards
1979-Steel-SW

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.07
2	ER VENT P	6.13A	2.70P	6.00	3.18
3	ER VENT S	6.13A	3.50S	6.00	3.25
4	Min	9.74A	5.98S	5.47	2.80
5	Min	9.74A	5.98P	5.47	2.66

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Intact Trim and Stability Summary
1979-Steel-FW

Item	Weight lbs		VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759		4.46	2.64A	0.00	----	
Constant	0		0.00	0.00	0.00	0	
Fuel Oil	535		2.27	1.29F	0.00	0	
Misc. Weights	8,551		8.17	0.49A	0.06P	0	
Displacement	21,845		5.86	1.70A	0.02P	0	
Stability Calculation				**Trim Calculation**			
KMt	7.97	ft		LCF Draft		2.86	ft
VCG	5.86	ft		LCB		1.65A	ft-MS
GMt (Solid)	2.11	ft		LCF		3.40A	ft-MS
FSc	0.00	ft		MT1in		2	ft-LT/in
GMt (Corrected)	2.10	ft		Trim		0.51	ft-F
				List		0.7P	deg
Specific Gravity	1.000						
Hull calcs from offsets				Tank calcs from tables			
Drafts							
Draft at A.P.	2.66	ft					
Draft at M.S.	2.91	ft					
Draft at F.P.	3.17	ft					
Draft at Aft Marks	2.65	ft					
Draft at Mid Marks	2.91	ft					
Draft at Fwd Marks	3.18	ft					

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Tankage and Cargo Summary
1979-Steel-FW

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	6,720	7.21	0.25F	0.08P	0	16.40A	16.40F
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
Totals	8,551	8.17	0.49A	0.06P	0		

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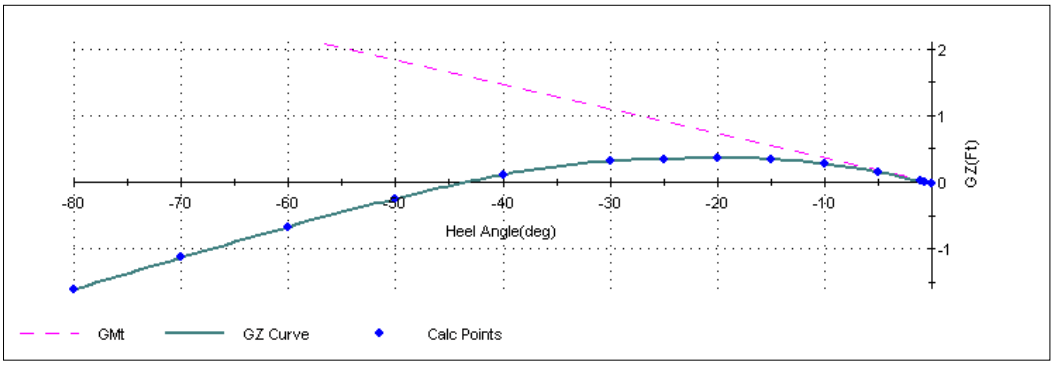
HECSALV 7.6.6beta

Righting Arm Summary
1979-Steel-FW

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.7P
Angle at Maximum GZ	**deg**	19.4P
Area to 19.4 deg	**ft-deg**	4.82
Maximum GZ	**ft**	0.36
Range of Positive GZ	**deg**	42.8

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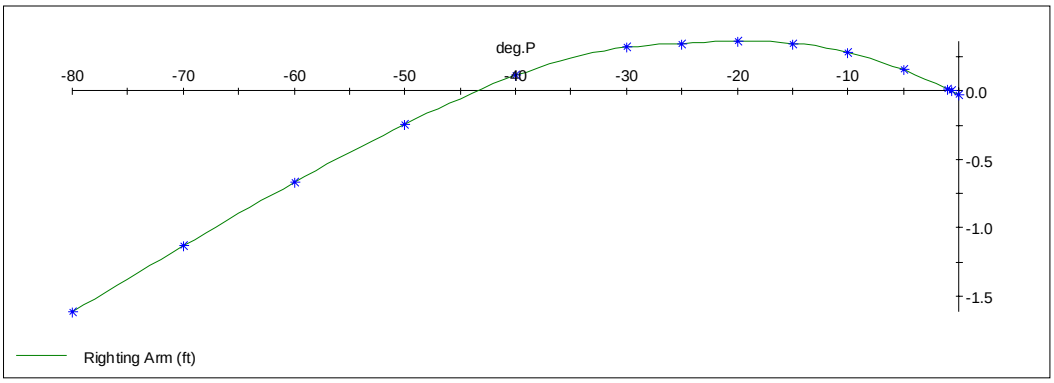
Draft/GZ Summary
1979-Steel-FW



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.02	2.66	3.17	0	0.2	0.00F	3
0.7P	0.00	2.66	3.17	0	2.2	0.00F	1
1.0P	0.01	2.66	3.17	0	0.2	0.00F	3
5.0P	0.15	2.64	3.16	0	0.0	0.01F	2
10.0P	0.28	2.57	3.15	0	0.1	0.00F	3
15.0P	0.35	2.45	3.14	0	0.0	0.00F	3
20.0P	0.36	2.28	3.11	0	-0.4	0.01F	3
25.0P	0.35	2.05	3.07	0	-1.0	0.01F	3
30.0P	0.32	1.75	3.01	0	0.1	0.00F	4
40.0P	0.11	1.01	2.88	0	0.1	0.00F	4
50.0P	-0.25	-0.01	2.77	0	0.0	0.00F	4
60.0P	-0.67	-1.53	2.66	0	0.0	0.00F	4
70.0P	-1.13	-4.50	2.52	0	-0.2	0.00F	5
80.0P	-1.61	-13.13	2.04	0	0.0	0.01F	8
Disp. of		Remaining	Intact Hull	21,845 lbs			

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HECSALV 7.6.6beta

Freeboards
1979-Steel-FW

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.03
2	ER VENT P	6.13A	2.70P	6.00	3.15
3	ER VENT S	6.13A	3.50S	6.00	3.22
4	Min	9.74A	5.98S	5.47	2.78
5	Min	9.74A	5.98P	5.47	2.63

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1979-Al-SW

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	7,503	7.67	0.11A	0.07P	0	
Displacement	20,797	5.56	1.63A	0.03P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.09	ft	LCF Draft		2.77	ft
VCG	5.56	ft	LCB		1.58A	ft-MS
GMt (Solid)	2.53	ft	LCF		3.45A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.52	ft	Trim		0.48	ft-F
			List		0.6P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.58	ft				
Draft at M.S.	2.82	ft				
Draft at F.P.	3.06	ft				
Draft at Aft Marks	2.57	ft				
Draft at Mid Marks	2.82	ft				
Draft at Fwd Marks	3.07	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1979-Al-SW

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	6,720	7.21	0.25F	0.08P	0	16.40A	16.40F
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
Totals	7,503	7.67	0.11A	0.07P	0		

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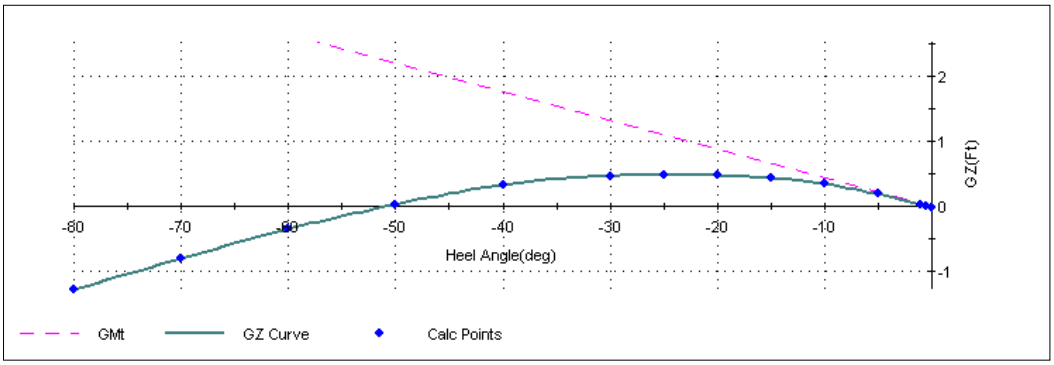
Righting Arm Summary
1979-Al-SW

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.6P
Angle at Maximum GZ	**deg**	23.0P
Area to 23. deg	**ft-deg**	7.88
Maximum GZ	**ft**	0.47
Range of Positive GZ	**deg**	50.2

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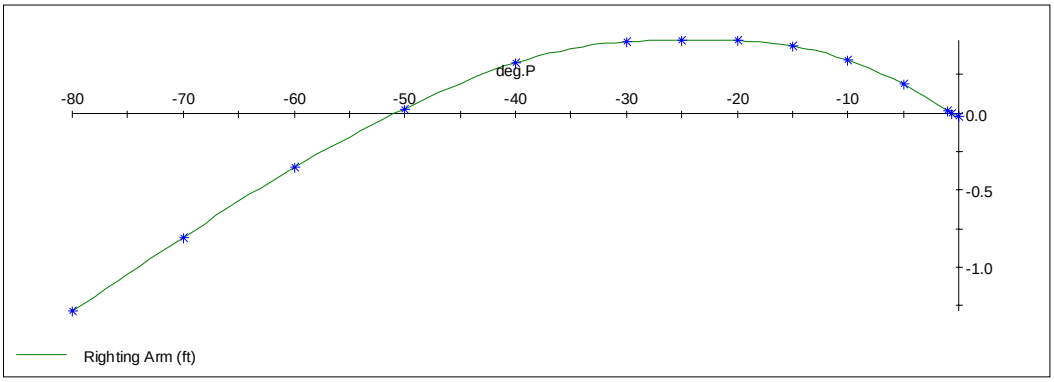
Draft/GZ Summary
1979-Al-SW



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.03	2.58	3.06	0	0.1	0.00F	3
0.6P	0.00	2.58	3.06	0	2.7	0.00F	1
1.0P	0.02	2.58	3.06	0	0.1	0.00F	3
5.0P	0.18	2.56	3.06	0	0.1	0.00F	3
10.0P	0.34	2.49	3.05	0	0.1	0.00F	3
15.0P	0.43	2.36	3.03	0	2.8	0.01F	3
20.0P	0.47	2.17	3.01	0	2.3	0.01F	3
25.0P	0.47	1.93	2.97	0	-1.3	0.01F	3
30.0P	0.46	1.63	2.90	0	-2.4	0.01F	3
40.0P	0.33	0.84	2.76	0	0.1	0.00F	4
50.0P	0.03	-0.25	2.63	0	-0.2	0.00F	4
60.0P	-0.36	-1.91	2.48	0	0.0	0.00F	4
70.0P	-0.81	-5.15	2.29	0	-0.2	0.01F	4
80.0P	-1.28	-14.51	1.53	0	-9.4	0.00F	9

Disp. of Remaining Intact Hull 20,797 lbs

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HECSALV 7.6.6beta

Freeboards
1979-AI-SW

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.13
2	ER VENT P	6.13A	2.70P	6.00	3.24
3	ER VENT S	6.13A	3.50S	6.00	3.30
4	Min	9.74A	5.98S	5.47	2.85
5	Min	9.74A	5.98P	5.47	2.72

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1979-AI-FW

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.4600	2.6400A	0.0000	----	
Constant	0	0.0000	0.0000	0.0000	0	
Fuel Oil	535	2.2653	1.2852F	0.0000	0	
Misc. Weights	7,503	7.6719	0.1100A	0.0717P	0	
Displacement	20,797	5.5622	1.6262A	0.0258P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.0483	ft	LCF Draft		2.8025	ft
VCG	5.5622	ft	LCB		1.5752A	ft-MS
GMt (Solid)	2.4861	ft	LCF		3.4232A	ft-MS
FSc	0.0043	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.4817	ft	Trim		0.5021	ft-F
			List		0.6P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.6027	ft				
Draft at M.S.	2.8537	ft				
Draft at F.P.	3.1048	ft				
Draft at Aft Marks	2.5931	ft				
Draft at Mid Marks	2.8537	ft				
Draft at Fwd Marks	3.1144	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1979-Al-FW

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.2653	1.2852F	0.0000	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.2653	1.2852F	0.0000	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	6,720	7.2083	0.2500F	0.0800P	0	16.4042A	16.4042F
AL CANOPY	783	11.6500	3.2000A	0.0000	0	16.4042A	16.4042F
Totals	7,503	7.6719	0.1100A	0.0717P	0		

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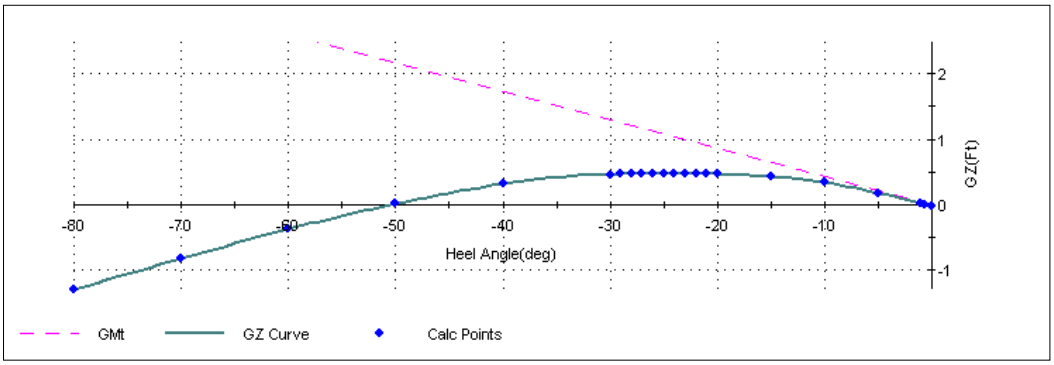
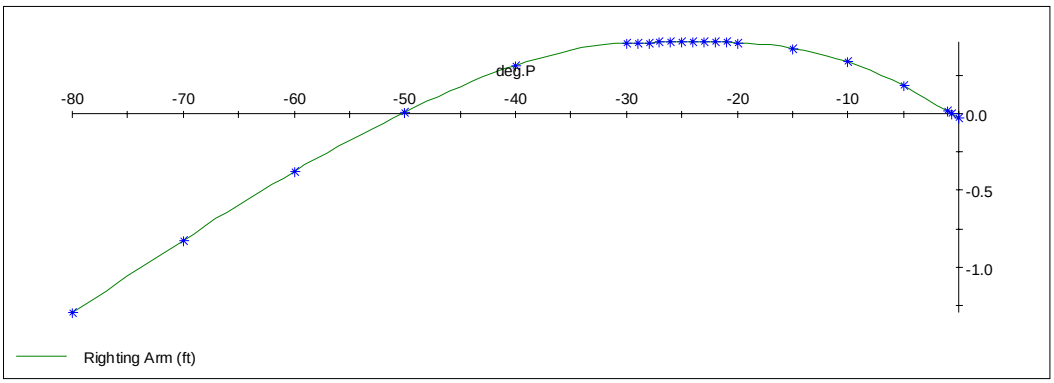
Righting Arm Summary
1979-Al-FW

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.6P
Angle at Maximum GZ	**deg**	23.3P
Area to 23.3 deg	**ft-deg**	7.80
Maximum GZ	**ft**	0.4704
Range of Positive GZ	**deg**	49.7

1979-Al-FW



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.0258	2.6032	3.1049	0	0.1	0.0010F	3
0.6P	0.0000	2.6027	3.1048	0	2.5	0.0008F	1
1.0P	0.0174	2.6024	3.1047	0	0.1	0.0010F	3
5.0P	0.1819	2.5863	3.0942	0	-0.1	0.0098F	2
10.0P	0.3386	2.5109	3.0904	0	0.1	0.0020F	3
15.0P	0.4277	2.3814	3.0779	0	-0.1	0.0039F	3
20.0P	0.4652	2.1982	3.0530	0	2.4	0.0077F	3
21.0P	0.4677	2.1520	3.0507	0	0.1	0.0012F	3
22.0P	0.4695	2.1065	3.0435	0	0.1	0.0013F	3
23.0P	0.4703	2.0588	3.0354	0	0.1	0.0014F	3
24.0P	0.4702	2.0089	3.0264	0	0.1	0.0014F	3
25.0P	0.4696	1.9573	3.0151	0	3.0	0.0033F	3
26.0P	0.4679	1.9029	3.0041	0	0.0	0.0016F	3
27.0P	0.4662	1.8461	2.9919	0	0.0	0.0017F	3
28.0P	0.4648	1.7866	2.9785	0	0.0	0.0018F	3
29.0P	0.4643	1.7239	2.9640	0	0.0	0.0018F	3
30.0P	0.4624	1.6586	2.9491	0	0.0	0.0019F	3
40.0P	0.3171	0.8841	2.8093	0	0.1	0.0013F	4
50.0P	0.0108	-0.1808	2.6858	0	-0.2	0.0021F	4
60.0P	-0.3756	-1.8019	2.5569	0	0.2	0.0048F	4
70.0P	-0.8239	-4.9596	2.3886	0	-0.2	0.0097F	4
80.0P	-1.2973	-14.1249	1.7582	0	-0.1	0.0011F	9

Disp. of Remaining Intact Hull 20,797 lbs

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Freeboards
1979-Al-FW

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.3685F	2.7000P	6.0000	3.0971
2	ER VENT P	6.1315A	2.7000P	6.0000	3.2094
3	ER VENT S	6.1315A	3.5000S	6.0000	3.2741
4	Min	9.7435A	5.9800S	5.4700	2.8242
5	Min	9.7435A	5.9800P	5.4700	2.6994

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Intact Trim and Stability Summary
2005

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.26	1.29F	0.00	0	
Misc. Weights	8,650	8.01	0.52A	0.06P	0	
Displacement	21,944	5.81	1.71A	0.02P	0	
Stability Calculation			**Trim Calculation**			
KMt	7.96	ft	LCF Draft		2.87	ft
VCG	5.81	ft	LCB		1.65A	ft-MS
GMt (Solid)	2.15	ft	LCF		3.40A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.15	ft	Trim		0.51	ft-F
			List		0.7P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.66	ft				
Draft at M.S.	2.92	ft				
Draft at F.P.	3.17	ft				
Draft at Aft Marks	2.65	ft				
Draft at Mid Marks	2.92	ft				
Draft at Fwd Marks	3.18	ft				

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Tankage and Cargo Summary
2005

Fuel Oil

	Weight	%	Capacity	VCG	LCG	TCG	FSmom	Density	Volume		API	Temp
	lbs	Full	lbs	ft-BL	ft-MS	ft-CL	ft-LT	lb/ft3	gal	bbls	Gravity	deg F
FUEL	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight	VCG	LCG	TCG	FSmom	Aft Bound	Fwd Bound
	lbs	ft-BL	ft-MS	ft-CL	ft-LT	ft-MS	ft-MS
PASSENGERS	6,720	7.21	0.25F	0.08P	0	16.40A	16.40F
WOOD CANOPY	1,930	10.82	3.20A	0.00	0	16.40A	16.40F
Totals	8,650	8.01	0.52A	0.06P	0		

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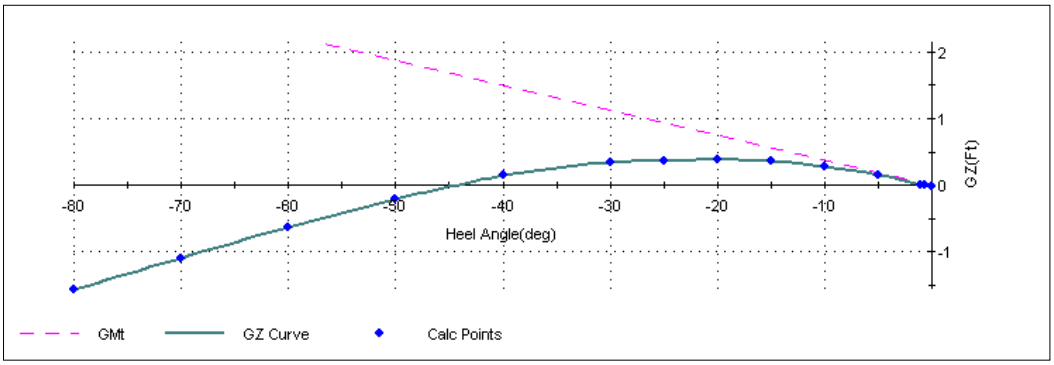
HECSALV 7.6.6beta

Righting Arm Summary
2005

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.7P
Angle at Maximum GZ	**deg**	20.0P
Area to 20. deg	**ft-deg**	4.99
Maximum GZ	**ft**	0.38
Range of Positive GZ	**deg**	43.8

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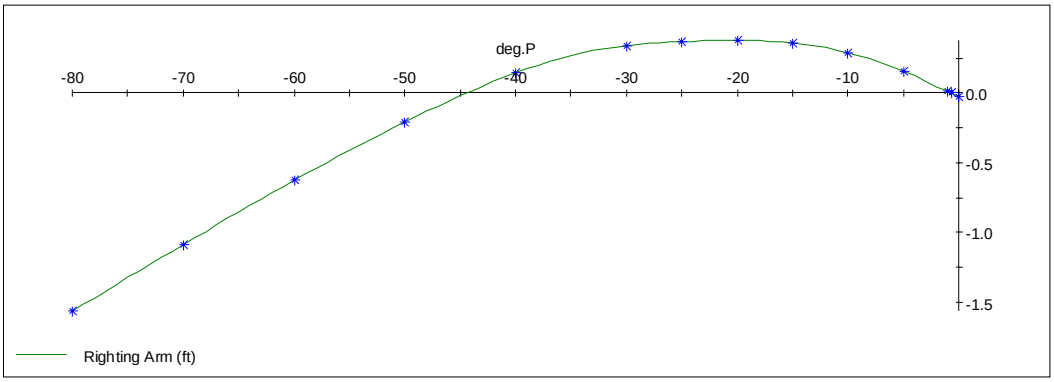
Draft/GZ Summary
2005



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.02	2.66	3.18	0	0.2	0.00F	3
0.7P	0.00	2.66	3.17	0	2.3	0.00F	1
1.0P	0.01	2.66	3.17	0	0.2	0.00F	3
5.0P	0.16	2.65	3.16	0	0.0	0.01F	2
10.0P	0.29	2.58	3.16	0	0.1	0.00F	3
15.0P	0.36	2.46	3.14	0	0.0	0.00F	3
20.0P	0.38	2.29	3.12	0	-0.4	0.01F	3
25.0P	0.37	2.06	3.08	0	-1.0	0.01F	3
30.0P	0.34	1.76	3.02	0	0.1	0.00F	4
40.0P	0.14	1.02	2.89	0	0.1	0.00F	4
50.0P	-0.21	0.01	2.78	0	0.1	0.00F	4
60.0P	-0.63	-1.50	2.66	0	0.0	0.00F	4
70.0P	-1.09	-4.45	2.53	0	-0.2	0.00F	5
80.0P	-1.56	-13.04	2.06	0	0.0	0.01F	8

Disp. of Remaining Intact Hull 21,944 lbs

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Ethan Allen

Freeboards
2005

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.03
2	ER VENT P	6.13A	2.70P	6.00	3.14
3	ER VENT S	6.13A	3.50S	6.00	3.21
4	Min	9.74A	5.98S	5.47	2.77
5	Min	9.74A	5.98P	5.47	2.63

ETHAN ALLEN
Stability Analysis

46 CFR - PART 170 - STABILITY REQUIREMENTS FOR ALL INSPECTED VESSELS
SUBPART E - Weather Criteria
§170.170(a) Calculations Required

Load Case	Draft (ft)	P (LT/ft^2)	A (ft^2)	H (ft)	W (LT)	TAN (T)	TAN 14^o	GM_{req} (ft)	GM_{actual} (ft)	
1964-SW	2.73	0.0025	164.9	3.62	8.93	0.22	0.25	0.76	2.81	PASS
1979-Steel-SW	2.83	0.0025	379.4	6.59	9.75	0.21	0.25	3.03	2.15	FAIL
1979-Steel-FW	2.86	0.0025	378.3	6.59	9.75	0.21	0.25	3.06	2.10	FAIL
1979-Al-SW	2.77	0.0025	381.5	6.59	9.28	0.22	0.25	3.13	2.52	FAIL
1979-Al-FW	2.80	0.0025	380.4	6.59	9.28	0.21	0.25	3.16	2.48	FAIL
2005-FW	2.87	0.0025	334.9	5.98	9.80	0.21	0.25	2.45	2.15	FAIL

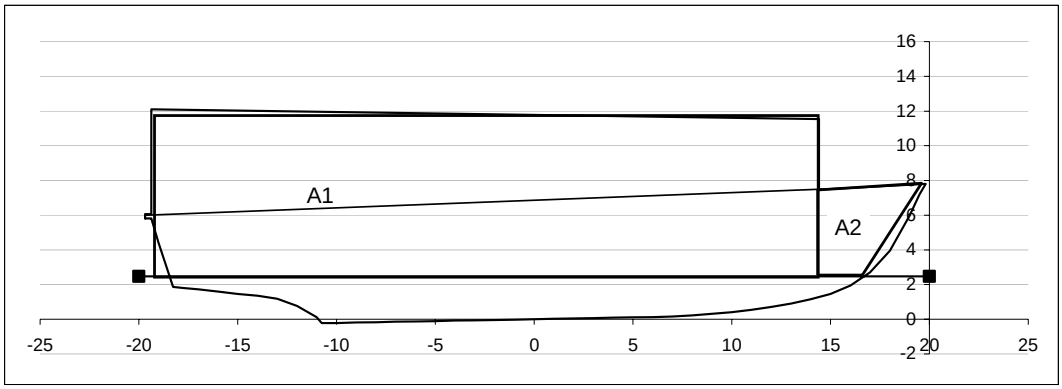
$GM \geq PAH / (W \tan(T))$ (ft)

Where: P = $0.0025 + (L/14200)^2$ (protected)
L = 33.5 feet
B = 12.4 feet
D = 5.4583 feet (freeboard depth)

Areas & Centers for Wind Heel Calculation

Load Case	Draft (ft)	A1 (ft^2)	A2 (ft^2)	A (ft^2)	H1 (ft)	H2 (ft)	H (ft)	
1964-SW	2.73	145.2	19.7	164.9	3.50	4.53	3.62	(No Canopy)
1979-Steel-SW	2.83	359.8	19.5	379.4	6.71	4.51	6.59	
1979-Steel-FW	2.86	358.8	19.5	378.3	6.71	4.50	6.59	
1979-Al-SW	2.77	361.9	19.6	381.5	6.71	4.52	6.59	
1979-Al-FW	2.80	360.9	19.6	380.4	6.71	4.51	6.59	
2005-FW	2.87	315.4	19.4	334.9	6.07	4.50	5.98	

A1 = Area of hull and canopy profile area above the waterline
= (7 - Draft) x 34.0 ft^2 no canopy
= (13.41 - Draft) x 34.0 ft^2 canvas canopy
= (12.15 - Draft) x 34.0 ft^2 wood canopy
A2 = Area of hull profile area above the waterline
= (8.0 - Draft)/2 x (0.629xDraft + 5.77) ft^2
H1 = centroid of area A1 = 3.5 no canopy
= centroid of area A1 = 6.71 canvas canopy
= centroid of area A1 = 6.07 wood canopy
H2 = centroid of area A2 = (8.0 - Draft)/3 x (0.629xDraft + 11.17) / (0.629xDraft + 5.77) + Draft/2



ETHAN ALLEN
Stability Analysis

46 CFR - PART 170 - STABILITY REQUIREMENTS FOR ALL INSPECTED VESSELS
SUBPART E - Weather Criteria
§170.170(a) Calculations Required

Load Case	Weight (lb)	140# Pax	Draft (ft)	P (LT/ft^2)	A (ft^2)	H (ft)	W (LT)	TAN (T)	TAN 14^o	GM_{req} (ft)	GM_{actual} (ft)	
1964-SW	26040	186	3.75	0.0025	127.8	3.61	17.56	0.14	0.25	0.48	0.62	PASS
1979-Steel-SW	0	0	2.44	0.0025	393.4	6.60	6.75	0.24	0.25	3.96	3.43	FAIL
1979-Steel-FW	0	0	2.47	0.0025	392.3	6.60	6.75	0.24	0.25	3.99	3.39	FAIL
1979-Al-SW	0	0	2.38	0.0025	395.6	6.60	6.28	0.25	0.25	4.19	4.01	FAIL
1979-Al-FW	0	0	2.40	0.0025	394.8	6.60	6.28	0.25	0.25	4.21	3.98	FAIL
2005-FW	2940	21	2.65	0.0025	342.8	5.99	8.11	0.23	0.25	2.80	2.80	PASS

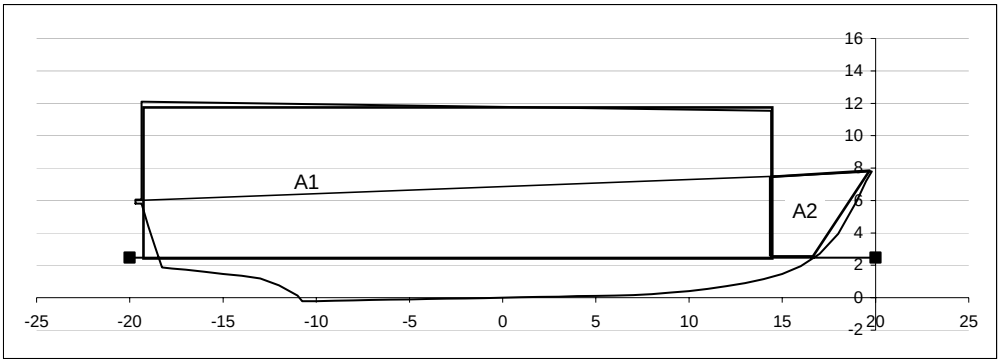
$GM \geq PAH / (W \tan(T))$ (ft)

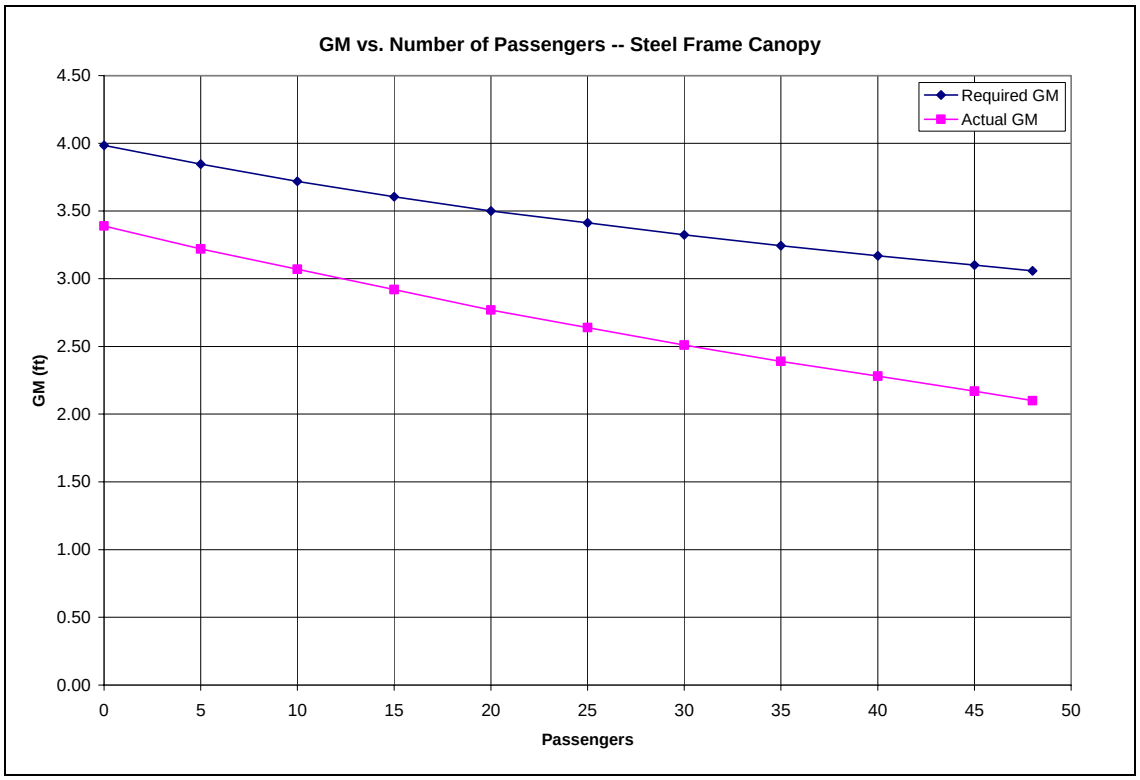
Where: P = $0.0025 + (L/14200)^2$ (protected)
L = 33.5 feet
B = 12.4 feet
D = 5.4583 feet (freeboard depth)

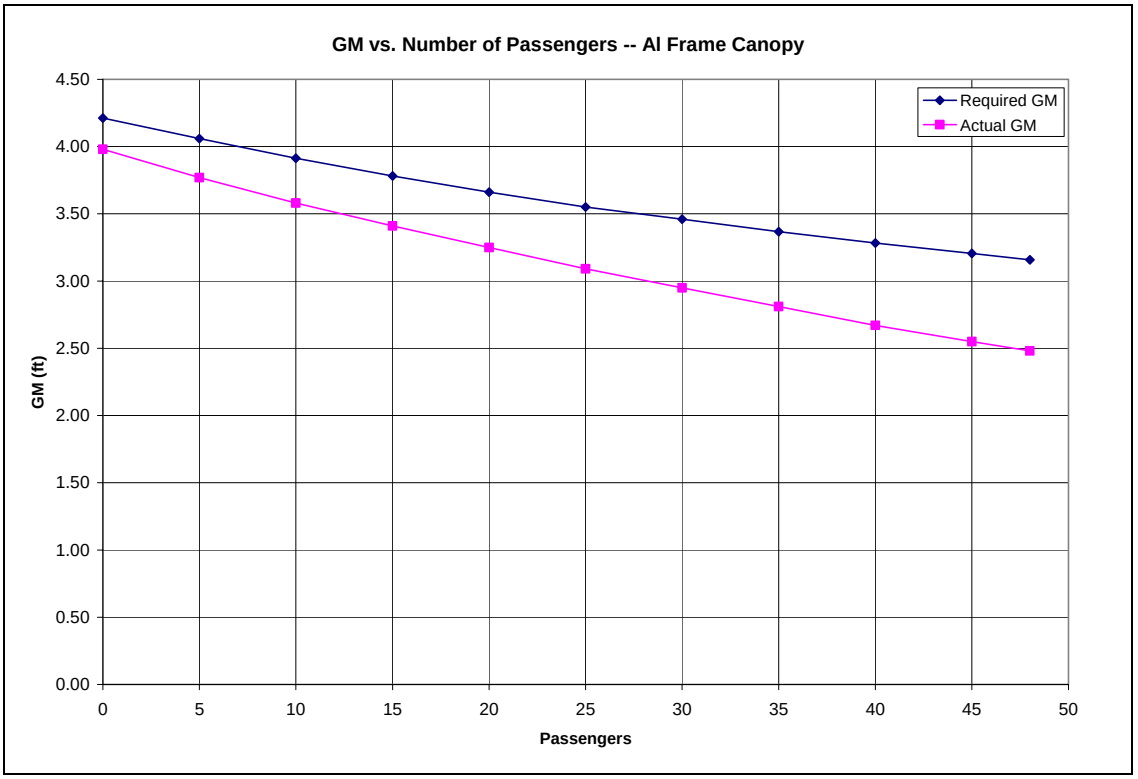
Areas & Centers for Wind Heel Calculation

Load Case	Draft (ft)	A1 (ft^2)	A2 (ft^2)	A (ft^2)	H1 (ft)	H2 (ft)	H (ft)	
1964-SW	3.75	110.5	17.3	127.8	3.50	4.34	3.61	(No Canopy)
1979-Steel-SW	2.44	373.1	20.3	393.4	6.71	4.60	6.60	
1979-Steel-FW	2.47	372.1	20.2	392.3	6.71	4.59	6.60	
1979-Al-SW	2.38	375.1	20.4	395.6	6.71	4.61	6.60	
1979-Al-FW	2.40	374.5	20.4	394.8	6.71	4.61	6.60	
2005-FW	2.65	322.9	19.9	342.8	6.07	4.55	5.99	

A1 = Area of hull and canopy profile area above the waterline
= (7 - Draft) x 34.0 ft^2 no canopy
= (13.41 - Draft) x 34.0 ft^2 canvas canopy
= (12.15 - Draft) x 34.0 ft^2 wood canopy
A2 = Area of hull profile area above the deck
= (8.0 - Draft)/2 x (0.629xDraft + 5.77) ft^2
H1 = centroid of area A1 = 3.5 no canopy
= centroid of area A1 = 6.71 canvas canopy
= centroid of area A1 = 6.07 wood canopy
H2 = centroid of area A2 = (8.0 - Draft)/3 x (0.629xDraft + 11.17) / (0.629xDraft + 5.77) + Draft/2




GM vs. Number of Passengers -- Steel Frame Canopy
Required GM
Actual GM
GM (ft)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
5
10
15
20
25
30
35
40
45
50
Passengers


GM vs. Number of Passengers -- Al Frame Canopy
Required GM
Actual GM
GM (ft)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
5
10
15
20
25
30
35
40
45
50
Passengers

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Intact Trim and Stability Summary
1964-Pass-170.170

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	26,040	7.21	0.25F	0.08P	0	
Displacement	39,334	6.25	0.67A	0.05P	0	
Stability Calculation			**Trim Calculation**			
KMt	6.87	ft	LCF Draft		3.75	ft
VCG	6.25	ft	LCB		0.47A	ft-MS
GMt (Solid)	0.62	ft	LCF		2.49A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	0.62	ft	Trim		1.94	ft-F
			List		4.9P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.93	ft				
Draft at M.S.	3.90	ft				
Draft at F.P.	4.86	ft				
Draft at Aft Marks	2.89	ft				
Draft at Mid Marks	3.90	ft				
Draft at Fwd Marks	4.90	ft				

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Tankage and Cargo Summary
1964-Pass-170.170

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	----	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	26,040	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	26,040	7.21	0.25F	0.08P	0		

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
2005-Pass-170.170

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.26	1.29F	0.00	0	
Misc. Weights	4,870	8.64	1.12A	0.05P	0	
Displacement	18,164	5.52	2.12A	0.01P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.32	ft	LCF Draft		2.65	ft
VCG	5.52	ft	LCB		2.10A	ft-MS
GMt (Solid)	2.80	ft	LCF		3.74A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.80	ft	Trim		0.12	ft-F
			List		0.3P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.60	ft				
Draft at M.S.	2.66	ft				
Draft at F.P.	2.72	ft				
Draft at Aft Marks	2.60	ft				
Draft at Mid Marks	2.66	ft				
Draft at Fwd Marks	2.73	ft				

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Tankage and Cargo Summary
2005-Pass-170.170

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	bbls	API Gravity	Temp deg F
FUEL	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2	----	60.0
Totals	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
WOOD CANOPY	1,930	10.82	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	2,940	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	4,870	8.64	1.12A	0.05P	0		

ETHAN ALLEN
Stability Analysis

46 CFR - PART 170 - STABILITY REQUIREMENTS FOR ALL INSPECTED VESSELS
SUBPART E - Weather Criteria -
§170.173 - Criterion for vessels of unusual proportion and form

(e)(2) For protected routes, there must be --
(i) The righting arm curve must be positive to at least 25 degrees of heel;
(ii) No downflooding point to at least 15 degrees; and
(iii) at least 10 foot-degrees of energy to the smallest of the following angles:
(A) Angle of maximum righting arm
(B) Angle of downflooding
(C) 40 degrees

		174.145 Stability Criteria		
		(i) 25	(ii) 15	(iii) 10
Loading Conditions	1964-SW	56.54	43.66	12.5
	1979-Steel-SW	43.47	42.88	**4.9**
	1979-Steel-FW	43.12	42.61	**4.8**
	1979-Al-SW	50.72	43.32	**7.9**
	1979-Al-FW	50.28	43.05	**7.8**
	2005-FW	44.08	42.53	**5.0**

Angle	1964-SW GZ	1979-Steel-SW GZ	1979-Steel-FW GZ	1979-Al-SW GZ	1979-Al-FW GZ	2005-FW GZ
0	0.000	0.000	0.000	0.000	0.000	0.000
5	0.209	0.155	0.151	0.185	0.182	0.155
10	0.388	0.286	0.281	0.343	0.339	0.289
15	0.495	0.351	0.347	0.432	0.428	0.360
20	0.550	0.365	0.362	0.468	0.465	0.380
25	0.570	0.347	0.346	0.471	0.470	0.368
30	0.578	0.318	0.317	0.463	0.462	0.344
40	0.489	0.122	0.112	0.326	0.317	0.144
50	0.232	-0.229	-0.246	0.028	0.011	-0.209
60	-0.123	-0.648	-0.669	-0.356	-0.376	-0.627
70	-0.560	-1.117	-1.134	-0.807	-0.824	-1.088
80	-1.033	-1.600	-1.613	-1.285	-1.297	-1.564
Max GZ	0.578	0.366	0.362	0.472	0.470	0.380
Angle @ Max GZ	29.4	19.2	19.4	23.0	23.3	20.0
Area to (A) (B) or (C)	12.54	4.89	4.82	7.88	7.80	4.99
Downflooding Angle	43.66	42.88	42.61	43.32	43.05	42.53
Angle @ 0 GZ	56.54	43.47	43.12	50.72	50.28	44.08

ETHAN ALLEN
Stability Analysis

46 CFR - PART 170 - STABILITY REQUIREMENTS FOR ALL INSPECTED VESSELS
SUBPART E - Weather Criteria -
§170.173 - Criterion for vessels of unusual proportion and form

(e)(2) For protected routes, there must be --
(i) The righting arm curve must be positive to at least 25 degrees of heel;
(ii) No downflooding point to at least 15 degrees; and
(iii) at least 10 foot-degrees of energy to the smallest of the following angles:
(A) Angle of maximum righting arm
(B) Angle of downflooding
(C) 40 degrees

		174.145 Stability Criteria		
		(i) 25	(ii) 15	(iii) 10
Loading Conditions	1964-SW	51.80	43.14	10.0
	1979-Steel-SW	59.29	44.75	10.1
	1979-Steel-FW	59.36	44.59	10.1
	1979-Al-SW	55.30	43.92	10.6
	1979-Al-FW	55.28	43.49	10.1
	2005-FW	58.57	44.34	10.5

Angle	1964-SW GZ	1979-Steel-SW GZ	1979-Steel-FW GZ	1979-Al-SW GZ	1979-Al-FW GZ	2005-FW GZ
0	0.000	0.000	0.000	0.000	0.000	0.000
5	0.183	0.249	0.249	0.212	0.212	0.240
10	0.345	0.438	0.439	0.387	0.387	0.430
15	0.440	0.542	0.546	0.488	0.490	0.540
20	0.485	0.586	0.592	0.533	0.537	0.580
25	0.499	0.591	0.598	0.544	0.549	0.590
30	0.499	0.581	0.590	0.539	0.548	0.580
40	0.364	0.536	0.543	0.451	0.454	0.530
50	0.068	0.330	0.332	0.192	0.192	0.300
60	-0.309	-0.025	-0.023	-0.170	-0.171	-0.050
70	-0.745	-0.508	-0.503	-0.621	-0.620	-0.530
80	-1.208	-1.040	-1.032	-1.112	-1.107	-1.050
Max GZ	0.502	0.593	0.599	0.544	0.549	0.590
Angle @ Max GZ	28.0	23.3	23.7	26.0	25.4	24.1
Area to (A) (B) or (C)	10.03	10.05	10.12	10.59	10.09	10.52
Downflooding Angle	43.14	44.75	44.59	43.92	43.49	44.34
Angle @ 0 GZ	51.80	59.29	59.36	55.30	55.28	58.57

Passengers	59	11	10	37	36	14
Displacement	21554	16665	16525	19257	19117	17184
Draft	2.82	2.54	2.55	2.69	2.71	2.59
GM	2.55	3.07	3.07	2.79	2.78	3.00

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1964-Pass-170.173

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,260	7.21	0.25F	0.08P	0	
Displacement	21,554	5.46	1.44A	0.03P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.01	ft	LCF Draft		2.82	ft
VCG	5.46	ft	LCB		1.37A	ft-MS
GMt (Solid)	2.55	ft	LCF		3.34A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.55	ft	Trim		0.62	ft-F
			List		0.7P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.57	ft				
Draft at M.S.	2.88	ft				
Draft at F.P.	3.19	ft				
Draft at Aft Marks	2.56	ft				
Draft at Mid Marks	2.88	ft				
Draft at Fwd Marks	3.20	ft				

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Tankage and Cargo Summary
1964-Pass-170.173

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	8,260	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	8,260	7.21	0.25F	0.08P	0		

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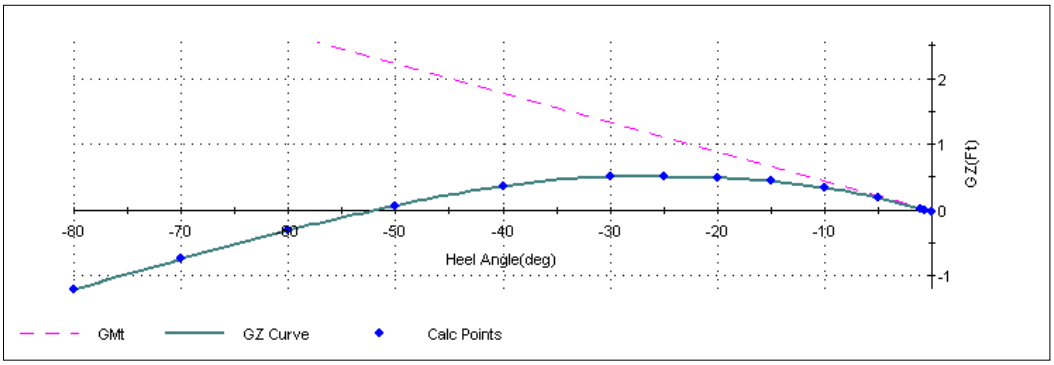
Righting Arm Summary
1964-Pass-170.173

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.7P
Angle at Maximum GZ	**deg**	28.0P
Area to 28. deg	**ft-deg**	10.03
Maximum GZ	**ft**	0.50
Range of Positive GZ	**deg**	51.2

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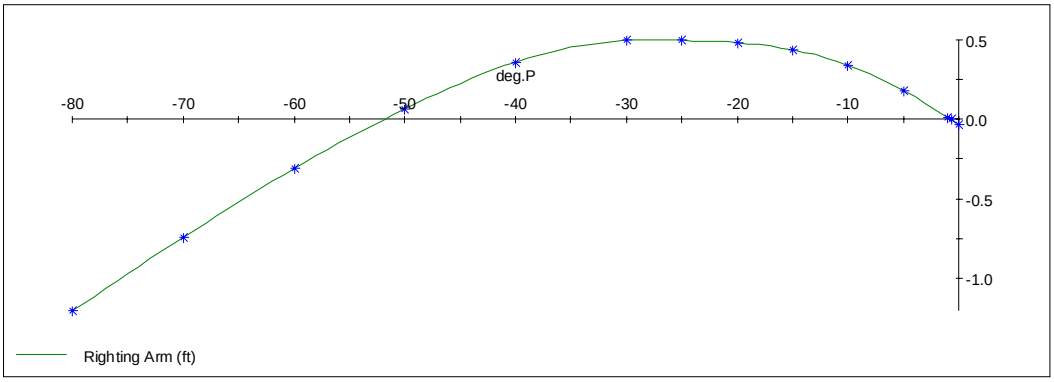
Draft/GZ Summary
1964-Pass-170.173



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.03	2.57	3.19	0	0.1	0.00F	3
0.7P	0.00	2.57	3.19	0	2.3	0.00F	1
1.0P	0.01	2.57	3.19	0	0.1	0.00F	3
5.0P	0.18	2.55	3.18	0	-0.1	0.01F	2
10.0P	0.34	2.48	3.17	0	0.1	0.00F	3
15.0P	0.44	2.34	3.17	0	-0.1	0.00F	3
20.0P	0.49	2.16	3.14	0	-0.5	0.01F	3
25.0P	0.50	1.92	3.11	0	-0.9	0.01F	3
30.0P	0.50	1.61	3.05	0	0.0	0.00F	4
40.0P	0.36	0.83	2.92	0	0.0	0.00F	4
50.0P	0.07	-0.25	2.83	0	0.0	0.00F	4
60.0P	-0.31	-1.89	2.74	0	0.0	0.00F	4
70.0P	-0.74	-5.09	2.64	0	-0.2	0.01F	4
80.0P	-1.21	-14.38	2.29	0	-1.2	0.00F	9
	Disp. of	Remaining	Intact Hull	21,554 lbs			

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Freeboards
1964-Pass-170.173

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.06
2	ER VENT P	6.13A	2.70P	6.00	3.20
3	ER VENT S	6.13A	3.50S	6.00	3.28
4	Min	9.74A	5.98S	5.47	2.84
5	Min	9.74A	5.98P	5.47	2.70

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1979-Steel-SW-Pass-170.173

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	3,371	9.65	1.62A	0.04P	0	
Displacement	16,665	5.44	2.31A	0.01P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.52	ft	LCF Draft		2.54	ft
VCG	5.44	ft	LCB		2.32A	ft-MS
GMt (Solid)	3.08	ft	LCF		3.92A	ft-MS
FSc	0.01	ft	MT1in		1	ft-LT/in
GMt (Corrected)	3.07	ft	Trim		0.06	ft-A
			List		0.1P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.56	ft				
Draft at M.S.	2.53	ft				
Draft at F.P.	2.50	ft				
Draft at Aft Marks	2.56	ft				
Draft at Mid Marks	2.53	ft				
Draft at Fwd Marks	2.50	ft				

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Tankage and Cargo Summary
1979-Steel-SW-Pass-170.173

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	1,540	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	3,371	9.65	1.62A	0.04P	0		

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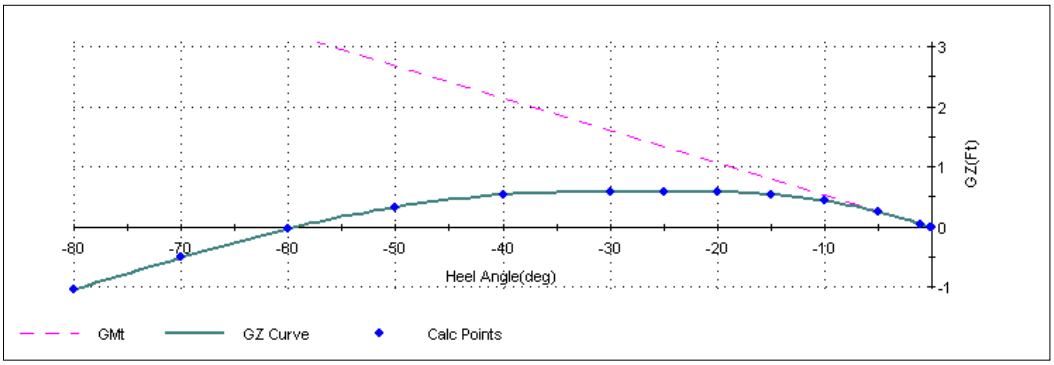
Righting Arm Summary
1979-Steel-SW-Pass-170.173

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.1P
Angle at Maximum GZ	**deg**	23.3P
Area to 23.3 deg	**ft-deg**	10.05
Maximum GZ	**ft**	0.59
Range of Positive GZ	**deg**	59.3

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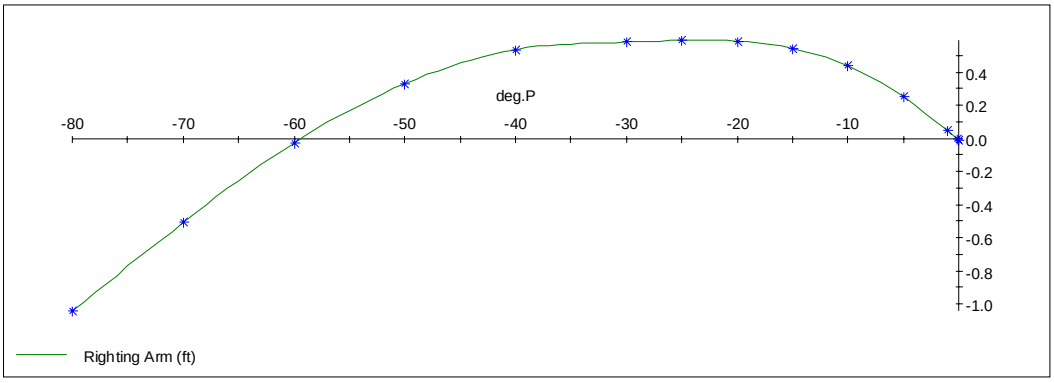
Draft/GZ Summary
1979-Steel-SW-Pass-170.173



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.01	2.56	2.50	0	0.0	0.00F	3
0.1P	0.00	2.56	2.50	0	1.5	0.00F	1
1.0P	0.05	2.56	2.50	0	0.0	0.00F	3
5.0P	0.25	2.53	2.49	0	0.0	0.00F	3
10.0P	0.44	2.45	2.48	0	-0.6	0.00F	3
15.0P	0.54	2.30	2.46	0	-1.7	0.01F	3
20.0P	0.59	2.10	2.43	0	-3.0	0.01F	3
25.0P	0.59	1.84	2.38	0	0.0	0.00F	4
30.0P	0.58	1.52	2.30	0	0.0	0.00F	4
40.0P	0.54	0.69	2.07	0	0.0	0.00F	4
50.0P	0.33	-0.49	1.80	0	0.1	0.01F	4
60.0P	-0.03	-2.38	1.46	0	-2.6	0.00F	5
70.0P	-0.51	-5.96	0.66	0	-4.1	0.00F	5
80.0P	-1.04	-16.21	-2.09	0	-2.7	0.00F	8

Disp. of Remaining Intact Hull 16,665 lbs

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HECSALV 7.6.6beta

Freeboards
1979-Steel-SW-Pass-170.173

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.47
2	ER VENT P	6.13A	2.70P	6.00	3.45
3	ER VENT S	6.13A	3.50S	6.00	3.47
4	Min	9.74A	5.98S	5.47	2.94
5	Min	9.74A	5.98P	5.47	2.91

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1979-Steel-FW-Pass-170.173

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	3,231	9.76	1.71A	0.03P	0	
Displacement	16,525	5.43	2.33A	0.01P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.50	ft	LCF Draft		2.55	ft
VCG	5.43	ft	LCB		2.34A	ft-MS
GMt (Solid)	3.07	ft	LCF		3.91A	ft-MS
FSc	0.01	ft	MT1in		1	ft-LT/in
GMt (Corrected)	3.07	ft	Trim		0.05	ft-A
			List		0.1P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.57	ft				
Draft at M.S.	2.55	ft				
Draft at F.P.	2.52	ft				
Draft at Aft Marks	2.57	ft				
Draft at Mid Marks	2.55	ft				
Draft at Fwd Marks	2.52	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1979-Steel-FW-Pass-170.173

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	1,400	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	3,231	9.76	1.71A	0.03P	0		

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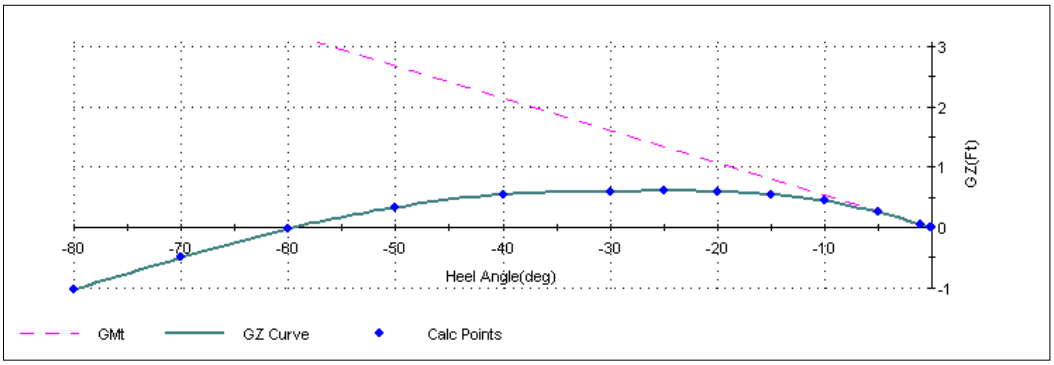
HECSALV 7.6.6beta

Righting Arm Summary
1979-Steel-FW-Pass-170.173

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.1P
Angle at Maximum GZ	**deg**	23.7P
Area to 23.7 deg	**ft-deg**	10.12
Maximum GZ	**ft**	0.60
Range of Positive GZ	**deg**	59.3

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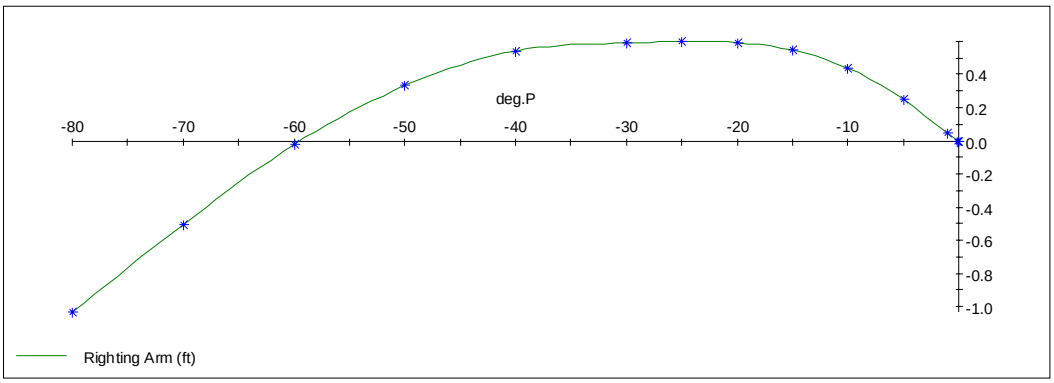
HECSALV 7.6.6beta

Draft/GZ Summary
1979-Steel-FW-Pass-170.173



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.01	2.57	2.52	0	0.0	0.00F	3
0.1P	0.00	2.57	2.52	0	1.3	0.00F	1
1.0P	0.05	2.57	2.52	0	0.0	0.00F	3
5.0P	0.25	2.55	2.51	0	0.0	0.00F	3
10.0P	0.44	2.46	2.50	0	-0.5	0.00F	3
15.0P	0.55	2.32	2.48	0	-1.6	0.01F	3
20.0P	0.59	2.12	2.44	0	-2.9	0.01F	3
25.0P	0.60	1.86	2.39	0	0.0	0.00F	4
30.0P	0.59	1.55	2.31	0	0.0	0.00F	4
40.0P	0.54	0.72	2.08	0	0.0	0.00F	4
50.0P	0.33	-0.45	1.81	0	0.2	0.01F	4
60.0P	-0.02	-2.30	1.48	0	-0.7	0.00F	5
70.0P	-0.50	-5.84	0.70	0	-3.5	0.00F	5
80.0P	-1.03	-15.94	-2.00	0	0.0	0.01F	8

Disp. of Remaining Intact Hull 16,525 lbs

JMS NA&SE
Ethan Allen

HECSALV 7.6.6beta

Freeboards
1979-Steel-FW-Pass-170.173

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.45
2	ER VENT P	6.13A	2.70P	6.00	3.44
3	ER VENT S	6.13A	3.50S	6.00	3.45
4	Min	9.74A	5.98S	5.47	2.92
5	Min	9.74A	5.98P	5.47	2.90

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1979-Al-SW-Pass-170.173

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	5,963	7.79	0.20A	0.07P	0	
Displacement	19,257	5.43	1.78A	0.02P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.23	ft	LCF Draft		2.69	ft
VCG	5.43	ft	LCB		1.74A	ft-MS
GMt (Solid)	2.80	ft	LCF		3.58A	ft-MS
FSc	0.00	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.79	ft	Trim		0.32	ft-F
			List		0.4P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.56	ft				
Draft at M.S.	2.72	ft				
Draft at F.P.	2.88	ft				
Draft at Aft Marks	2.55	ft				
Draft at Mid Marks	2.72	ft				
Draft at Fwd Marks	2.89	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1979-Al-SW-Pass-170.173

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	5,180	7.21	0.25F	0.08P	0	16.40A	16.40F
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
Totals	5,963	7.79	0.20A	0.07P	0		

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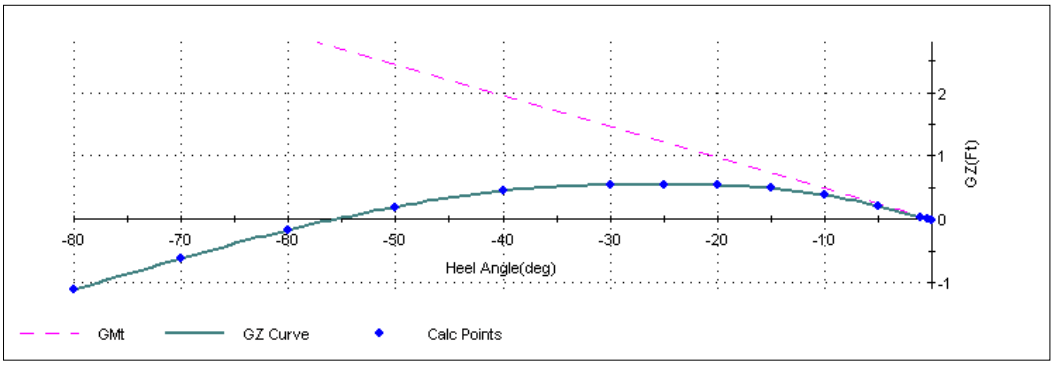
HECSALV 7.6.6beta

Righting Arm Summary
1979-Al-SW-Pass-170.173

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.4P
Angle at Maximum GZ	**deg**	26.0P
Area to 26. deg	**ft-deg**	10.59
Maximum GZ	**ft**	0.54
Range of Positive GZ	**deg**	55.2

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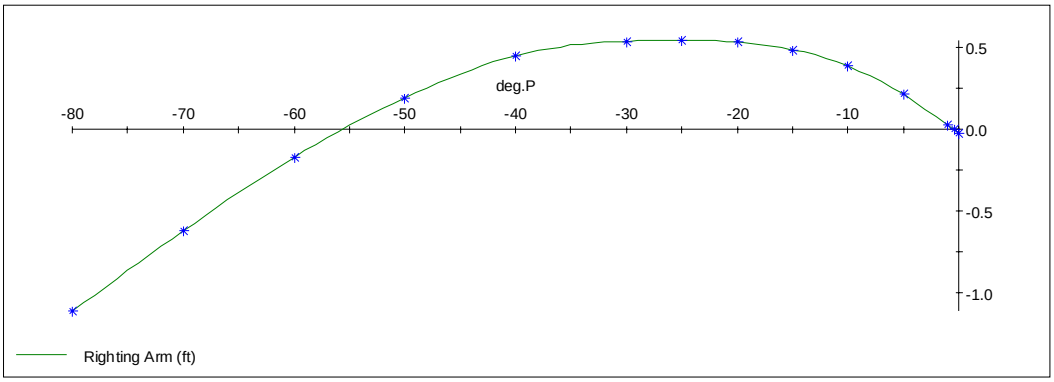
Draft/GZ Summary
1979-Al-SW-Pass-170.173



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.02	2.56	2.88	0	0.1	0.00F	3
0.4P	0.00	2.56	2.88	0	2.9	0.00F	1
1.0P	0.03	2.56	2.88	0	0.1	0.00F	3
5.0P	0.21	2.54	2.88	0	0.1	0.00F	3
10.0P	0.39	2.46	2.87	0	0.0	0.00F	3
15.0P	0.49	2.32	2.85	0	-0.5	0.00F	3
20.0P	0.53	2.12	2.83	0	-1.1	0.01F	3
25.0P	0.54	1.87	2.78	0	-1.9	0.01F	3
30.0P	0.54	1.56	2.72	0	0.0	0.00F	4
40.0P	0.45	0.75	2.54	0	-0.1	0.00F	4
50.0P	0.19	-0.38	2.36	0	-0.1	0.00F	4
60.0P	-0.17	-2.13	2.16	0	0.0	0.01F	4
70.0P	-0.62	-5.55	1.82	0	-0.5	0.00F	5
80.0P	-1.11	-15.34	0.47	0	-8.2	0.01F	8

Disp. of Remaining Intact Hull 19,257 lbs

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Freeboards
1979-Al-SW-Pass-170.173

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.25
2	ER VENT P	6.13A	2.70P	6.00	3.32
3	ER VENT S	6.13A	3.50S	6.00	3.37
4	Min	9.74A	5.98S	5.47	2.89
5	Min	9.74A	5.98P	5.47	2.80

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1979-Al-FW-Pass-170.173

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.4600	2.6400A	0.0000	----	
Constant	0	0.0000	0.0000	0.0000	0	
Fuel Oil	535	2.2653	1.2852F	0.0000	0	
Misc. Weights	5,823	7.8056	0.2139A	0.0692P	0	
Displacement	19,117	5.4176	1.7911A	0.0211P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.2009	ft	LCF Draft		2.7049	ft
VCG	5.4176	ft	LCB		1.7586A	ft-MS
GMt (Solid)	2.7833	ft	LCF		3.5673A	ft-MS
FSc	0.0047	ft	MT1in		1	ft-LT/in
GMt (Corrected)	2.7786	ft	Trim		0.3323	ft-F
			List		0.4P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.5742	ft				
Draft at M.S.	2.7403	ft				
Draft at F.P.	2.9064	ft				
Draft at Aft Marks	2.5678	ft				
Draft at Mid Marks	2.7403	ft				
Draft at Fwd Marks	2.9128	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1979-Al-FW-Pass-170.173

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.2653	1.2852F	0.0000	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.2653	1.2852F	0.0000	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
AL CANOPY	783	11.6500	3.2000A	0.0000	0	16.4042A	16.4042F
PASSENGERS	5,040	7.2083	0.2500F	0.0800P	0	16.4042A	16.4042F
Totals	5,823	7.8056	0.2139A	0.0692P	0		

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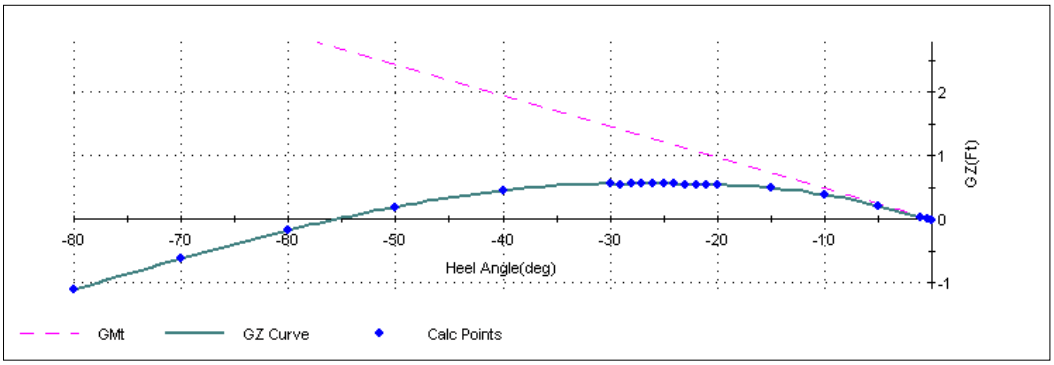
HECSALV 7.6.6beta

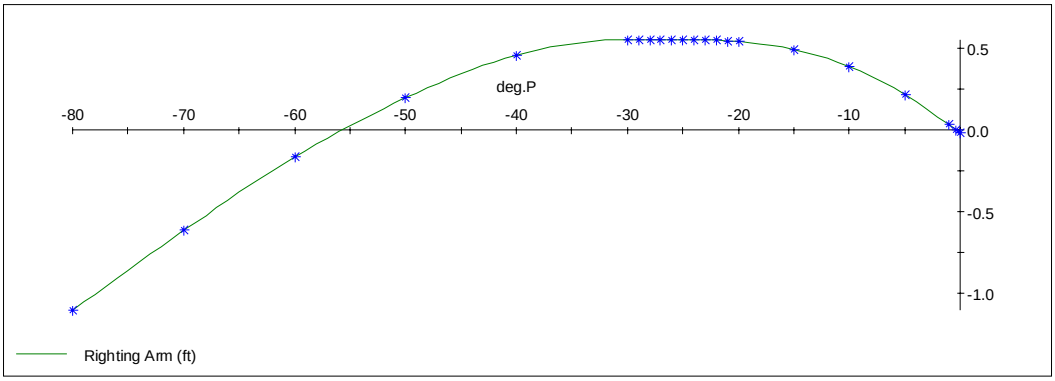
Righting Arm Summary
1979-Al-FW-Pass-170.173

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.4P
Angle at Maximum GZ	**deg**	25.4P
Area to 25.4 deg	**ft-deg**	10.09
Maximum GZ	**ft**	0.5487
Range of Positive GZ	**deg**	55.2

1979-Al-FW-Pass-170.173



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.0211	2.5745	2.9065	0	0.1	0.0010F	3
0.4P	0.0000	2.5742	2.9064	0	2.7	0.0007F	1
1.0P	0.0274	2.5737	2.9063	0	0.1	0.0010F	3
5.0P	0.2115	2.5519	2.9011	0	0.1	0.0006F	3
10.0P	0.3874	2.4743	2.8908	0	0.0	0.0023F	3
15.0P	0.4896	2.3370	2.8766	0	-0.4	0.0044F	3
20.0P	0.5368	2.1456	2.8503	0	-1.1	0.0068F	3
21.0P	0.5410	2.0982	2.8465	0	0.0	0.0014F	3
22.0P	0.5444	2.0511	2.8386	0	0.0	0.0014F	3
23.0P	0.5467	2.0019	2.8299	0	0.0	0.0015F	3
24.0P	0.5480	1.9506	2.8202	0	0.0	0.0016F	3
25.0P	0.5486	1.8970	2.8095	0	0.0	0.0017F	3
26.0P	0.5486	1.8412	2.7978	0	0.0	0.0017F	3
27.0P	0.5481	1.7831	2.7849	0	0.0	0.0018F	3
28.0P	0.5473	1.7227	2.7709	0	0.0	0.0020F	3
29.0P	0.5469	1.6596	2.7555	0	0.0	0.0021F	3
30.0P	0.5476	1.5932	2.7389	0	-0.1	0.0022F	3
40.0P	0.4543	0.7897	2.5643	0	0.0	0.0019F	4
50.0P	0.1916	-0.3250	2.3929	0	-0.1	0.0028F	4
60.0P	-0.1710	-2.0480	2.1953	0	-0.1	0.0053F	4
70.0P	-0.6197	-5.4068	1.8681	0	-0.3	0.0012F	5
80.0P	-1.1071	-15.0455	0.5904	0	-7.0	0.0079F	8

Disp. of Remaining Intact Hull 19,117 lbs

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Freeboards
1979-Al-FW-Pass-170.173

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.3685F	2.7000P	6.0000	3.2254
2	ER VENT P	6.1315A	2.7000P	6.0000	3.2998
3	ER VENT S	6.1315A	3.5000S	6.0000	3.3468
4	Min	9.7435A	5.9800S	5.4700	2.8715
5	Min	9.7435A	5.9800P	5.4700	2.7807

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Intact Trim and Stability Summary
2005-Pass-170.173

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.26	1.29F	0.00	0	
Misc. Weights	3,890	9.00	1.46A	0.04P	0	
Displacement	17,184	5.42	2.25A	0.01P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.43	ft	LCF Draft		2.59	ft
VCG	5.42	ft	LCB		2.25A	ft-MS
GMt (Solid)	3.01	ft	LCF		3.84A	ft-MS
FSc	0.01	ft	MT1in		1	ft-LT/in
GMt (Corrected)	3.00	ft	Trim		0.01	ft
			List		0.2P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.59	ft				
Draft at M.S.	2.59	ft				
Draft at F.P.	2.60	ft				
Draft at Aft Marks	2.59	ft				
Draft at Mid Marks	2.59	ft				
Draft at Fwd Marks	2.60	ft				

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Tankage and Cargo Summary
2005-Pass-170.173

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
WOOD CANOPY	1,930	10.82	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	1,960	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	3,890	9.00	1.46A	0.04P	0		

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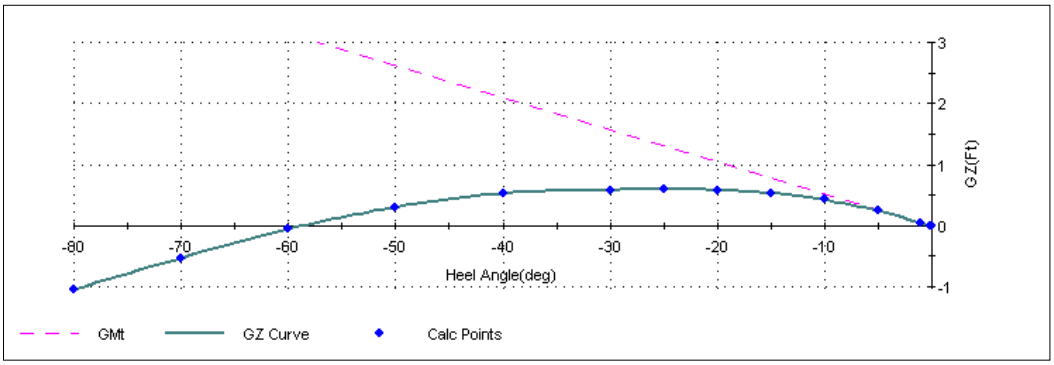
HECSALV 7.6.6beta

Righting Arm Summary
2005-Pass-170.173

No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.2P
Angle at Maximum GZ	**deg**	24.1P
Area to 24.1 deg	**ft-deg**	10.52
Maximum GZ	**ft**	0.59
Range of Positive GZ	**deg**	58.5

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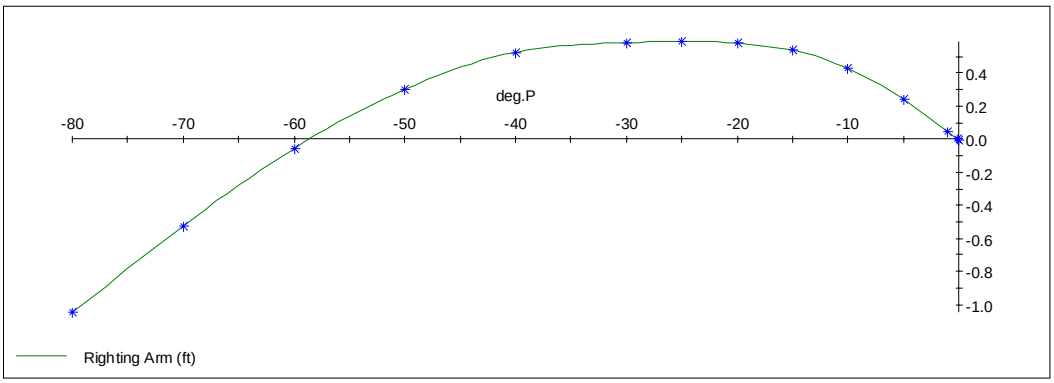
Draft/GZ Summary
2005-Pass-170.173



Angle (deg)	GZ ft	Draft Aft ft	Draft Fwd ft	Flooded lbs	CDisp lbs	CTrim ft	Iteration No.
0.0	-0.01	2.59	2.60	0	0.0	0.00F	3
0.2P	0.00	2.59	2.60	0	1.6	0.00F	1
1.0P	0.04	2.58	2.60	0	0.0	0.00F	3
5.0P	0.24	2.56	2.59	0	0.0	0.00F	3
10.0P	0.43	2.48	2.58	0	-0.5	0.00F	3
15.0P	0.54	2.34	2.56	0	-1.4	0.01F	3
20.0P	0.58	2.14	2.53	0	-2.6	0.01F	3
25.0P	0.59	1.89	2.48	0	0.0	0.00F	4
30.0P	0.58	1.58	2.40	0	0.0	0.00F	4
40.0P	0.53	0.76	2.18	0	0.0	0.00F	4
50.0P	0.30	-0.38	1.93	0	0.0	0.00F	4
60.0P	-0.05	-2.19	1.62	0	-0.5	0.01F	4
70.0P	-0.53	-5.67	0.95	0	-3.2	0.00F	5
80.0P	-1.05	-15.57	-1.46	0	-5.9	0.00F	8

Disp. of Remaining Intact Hull 17,184 lbs

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HECSALV 7.6.6beta

Freeboards
2005-Pass-170.173

No.	Name	Long. Loc.	Trsv. Loc.	Vert. Loc.	Freeboard
		ft-MS	ft-CL	ft-BL	ft
1	FWD VENT	1.37F	2.70P	6.00	3.40
2	ER VENT P	6.13A	2.70P	6.00	3.40
3	ER VENT S	6.13A	3.50S	6.00	3.42
4	Min	9.74A	5.98S	5.47	2.90
5	Min	9.74A	5.98P	5.47	2.86

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Stability Analysis

46 CFR - PART 171 - SPECIAL RULES PERTAINING TO VESSELS CARRYING PASSENGERS

SUBPART C - Large Vessels

§171.050 - Intact stability requirements for a mechanically propelled or a nonself-propelled vessel.

$GM \geq Nb / (KW \tan(T))$ (ft)

Where:
- N = number of passengers
- W = displacement of vessel in long tons.
- T = 14° or the angle of heel at which the deck edge is first submerged, whichever is less
- b = distance in feet from the centerline of the vessel to the geometric center of the passenger deck on one side of the centerline
- b = 2.5 feet
- K = 24 passengers/LT
- B = 12.4 feet
- D = 5.46 feet (freeboard depth)

Load Case	Draft (ft)	N	W (LT)	TAN (T)	TAN 14°	GM_{req} (ft)	GM_{actual} (ft)	
1964-SW	2.73	48	8.93	0.44	0.25	2.24	2.81	PASS
1979-Steel-SW	2.83	48	9.75	0.42	0.25	2.06	2.15	PASS
1979-Steel-FW	2.86	48	9.75	0.42	0.25	2.06	2.10	PASS
1979-Al-SW	2.77	48	9.28	0.43	0.25	2.16	2.52	PASS
1979-Al-FW	2.80	48	9.28	0.43	0.25	2.16	2.48	PASS
2005-FW	2.87	48	9.80	0.42	0.25	2.05	2.15	PASS

ETHAN ALLEN
Stability Analysis

46 CFR - PART 171 - SPECIAL RULES PERTAINING TO VESSELS CARRYING PASSENGERS
SUBPART C - Large Vessels
§171.050 - Intact stability requirements for a mechanically propelled or a nonself-propelled vessel.

$GM \geq Nb / (KW \tan(T))$ (ft)

Where:
- N = number of passengers
- W = displacement of vessel in long tons.
- T = 14° or the angle of heel at which the deck edge is first submerged, whichever is less
- b = distance in feet from the centerline of the vessel to the geometric center of the passenger deck on one side of the centerline
- b = 2.5 feet
- K = 24 passengers/LT
- B = 12.4 feet
- D = 5.46 feet (freeboard depth)

Load Case	Draft (ft)	N	W (LT)	TAN (T)	TAN 14°	GM_{req} (ft)	GM_{actual} (ft)	
1964-SW	2.81	58	9.56	0.43	0.25	2.53	2.57	PASS
1979-Steel-SW	2.84	49	9.81	0.42	0.25	2.09	2.13	PASS
1979-Steel-FW	2.86	48	9.75	0.42	0.25	2.06	2.10	PASS
1979-Al-SW	2.82	54	9.66	0.43	0.25	2.34	2.39	PASS
1979-Al-FW	2.85	54	9.66	0.42	0.25	2.34	2.34	PASS
2005-FW	2.87	49	9.86	0.42	0.25	2.08	2.12	PASS

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1964-Pass-171.05

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,120	7.21	0.25F	0.08P	0	
Displacement	21,414	5.45	1.45A	0.03P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.02	ft	LCF Draft		2.81	ft
VCG	5.45	ft	LCB		1.39A	ft-MS
GMt (Solid)	2.58	ft	LCF		3.35A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.57	ft	Trim		0.60	ft-F
			List		0.7P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.57	ft				
Draft at M.S.	2.87	ft				
Draft at F.P.	3.17	ft				
Draft at Aft Marks	2.56	ft				
Draft at Mid Marks	2.87	ft				
Draft at Fwd Marks	3.18	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1964-Pass-171.05

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
PASSENGERS	8,120	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	8,120	7.21	0.25F	0.08P	0		

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HECSALV 7.6.6beta

Intact Trim and Stability Summary
1979-Steel-SW-Pass-171.05

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,691	8.16	0.48A	0.06P	0	
Displacement	21,985	5.87	1.69A	0.02P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.00	ft	LCF Draft		2.84	ft
VCG	5.87	ft	LCB		1.63A	ft-MS
GMt (Solid)	2.13	ft	LCF		3.42A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.13	ft	Trim		0.50	ft-F
			List		0.7P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.64	ft				
Draft at M.S.	2.89	ft				
Draft at F.P.	3.14	ft				
Draft at Aft Marks	2.63	ft				
Draft at Mid Marks	2.89	ft				
Draft at Fwd Marks	3.15	ft				

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HECSALV 7.6.6beta

Tankage and Cargo Summary
1979-Steel-SW-Pass-171.05

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,860	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	8,691	8.16	0.48A	0.06P	0		

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Intact Trim and Stability Summary
1979-Steel-FW-Pass-171.05

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,551	8.17	0.49A	0.06P	0	
Displacement	21,845	5.86	1.70A	0.02P	0	
Stability Calculation			**Trim Calculation**			
KMt	7.97	ft	LCF Draft		2.86	ft
VCG	5.86	ft	LCB		1.65A	ft-MS
GMt (Solid)	2.11	ft	LCF		3.40A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.10	ft	Trim		0.51	ft-F
			List		0.7P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.66	ft				
Draft at M.S.	2.91	ft				
Draft at F.P.	3.17	ft				
Draft at Aft Marks	2.65	ft				
Draft at Mid Marks	2.91	ft				
Draft at Fwd Marks	3.18	ft				

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Tankage and Cargo Summary
1979-Steel-FW-Pass-171.05

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
STEEL CANOPY	1,831	11.71	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,720	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	8,551	8.17	0.49A	0.06P	0		

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Intact Trim and Stability Summary
1979-Al-SW-Pass - 171.050

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,343	7.63	0.07A	0.07P	0	
Displacement	21,637	5.63	1.55A	0.03P	0	
Stability Calculation			**Trim Calculation**			
KMt	8.02	ft	LCF Draft		2.82	ft
VCG	5.63	ft	LCB		1.50A	ft-MS
GMt (Solid)	2.39	ft	LCF		3.38A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.39	ft	Trim		0.56	ft-F
			List		0.7P	deg
Specific Gravity	1.025					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.60	ft				
Draft at M.S.	2.88	ft				
Draft at F.P.	3.16	ft				
Draft at Aft Marks	2.59	ft				
Draft at Mid Marks	2.88	ft				
Draft at Fwd Marks	3.17	ft				

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Tankage and Cargo Summary
1979-Al-SW-Pass - 171.050

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	7,560	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	8,343	7.63	0.07A	0.07P	0		

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Intact Trim and Stability Summary
1979-Al-FW-Pass-171.050

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.27	1.29F	0.00	0	
Misc. Weights	8,343	7.63	0.07A	0.07P	0	
Displacement	21,637	5.63	1.55A	0.03P	0	
Stability Calculation			**Trim Calculation**			
KMt	7.97	ft	LCF Draft		2.85	ft
VCG	5.63	ft	LCB		1.49A	ft-MS
GMt (Solid)	2.35	ft	LCF		3.36A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.34	ft	Trim		0.58	ft-F
			List		0.7P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.62	ft				
Draft at M.S.	2.91	ft				
Draft at F.P.	3.20	ft				
Draft at Aft Marks	2.61	ft				
Draft at Mid Marks	2.91	ft				
Draft at Fwd Marks	3.21	ft				

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Tankage and Cargo Summary
1979-Al-FW-Pass-171.050

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.3	721	2.27	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
AL CANOPY	783	11.65	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	7,560	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	8,343	7.63	0.07A	0.07P	0		

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Intact Trim and Stability Summary
2005-Pass-171.05

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-LT	
Light Ship	12,759	4.46	2.64A	0.00	----	
Constant	0	0.00	0.00	0.00	0	
Fuel Oil	535	2.26	1.29F	0.00	0	
Misc. Weights	8,790	8.00	0.51A	0.06P	0	
Displacement	22,084	5.82	1.70A	0.02P	0	
Stability Calculation			**Trim Calculation**			
KMt	7.95	ft	LCF Draft		2.87	ft
VCG	5.82	ft	LCB		1.64A	ft-MS
GMt (Solid)	2.13	ft	LCF		3.39A	ft-MS
FSc	0.00	ft	MT1in		2	ft-LT/in
GMt (Corrected)	2.12	ft	Trim		0.53	ft-F
			List		0.7P	deg
Specific Gravity	1.000					
Hull calcs from offsets			Tank calcs from tables			
Drafts						
Draft at A.P.	2.67	ft				
Draft at M.S.	2.93	ft				
Draft at F.P.	3.19	ft				
Draft at Aft Marks	2.66	ft				
Draft at Mid Marks	2.93	ft				
Draft at Fwd Marks	3.20	ft				

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Tankage and Cargo Summary
2005-Pass-171.05

Fuel Oil

	Weight lbs	% Full	Capacity lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Density lb/ft3	Volume gal	Volume bbls	API Gravity	Temp deg F
FUEL	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2	---	60.0
Totals	535	74.2	721	2.26	1.29F	0.00	0	53.400	75	2		

Misc. Weights

	Weight lbs	VCG ft-BL	LCG ft-MS	TCG ft-CL	FSmom ft-LT	Aft Bound ft-MS	Fwd Bound ft-MS
WOOD CANOPY	1,930	10.82	3.20A	0.00	0	16.40A	16.40F
PASSENGERS	6,860	7.21	0.25F	0.08P	0	16.40A	16.40F
Totals	8,790	8.00	0.51A	0.06P	0		

PASSENGER VESSEL ETHAN ALLEN
STABILITY ANALYSIS

PRELIMINARY REPORT
DELIVERABLE 2: TASK 6

prepared for:

NATIONAL TRANSPORTATION SAFETY BOARD
MS1 Office of Marine Safety
490 L'Enfant Plaza East, SW • Washington, DC 20594

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21 April 2006
Report: # 06-118-02

TABLE OF CONTENTS

EXECUTIVE SUMMARY ---------- 1
DESCRIPTION OF COMPUTER MODEL---------- 1
VESSEL PARTICULARS---------- 1
ASSUMPTIONS ---------- 1
RESULTS ---------- 2

APPENDICES

TRANSVERSE STABILITY ---------- APPENDIX A
PASSENGER WEIGHT AND CENTERS ---------- APPENDIX B
ENGINE COMPARTMENT FLOODING DETAIL RESULTS ---------- APPENDIX C
FORWARD COMPARTMENT FLOODING DETAIL RESULTS ---------- APPENDIX D
TANK TABLES ---------- APPENDIX E
TRANSVERSE PASSENGER WEIGHT SHIFT DETAIL RESULTS ---------- APPENDIX F

REFERENCES

1. JMS Report – PASSENGER VESSEL ETHAN ALLEN STABILITY ANALYSIS, Deliverable 1 – Tasks 1-5, #06-118-01, Rev 2.
2. *Marine Casualty Response, Salvage Engineering*, JMS Naval Architects & Salvage Engineers 1999

EXECUTIVE SUMMARY

On October 2, 2005 the NY state certified vessel Ethan Allen was touring Lake George with 47 passengers and one NY State licensed crewmember on board. The vessel proceeded northbound and approached an area on the lake called Cramer Point when the master began a turn to starboard. According to most of the passengers, the vessel heeled to port and capsized. After remaining inverted on the surface for a short period, the vessel subsequently sank. The master and 27 passengers survived. Twenty passengers died.

At the request of NTSB, JMS has performed intact stability calculations for the passenger vessel ETHAN ALLEN. Results of the intact stability analysis, Tasks 1-5, are presented in Ref. 1. This report presents the results of Task 6 which evaluates the effect of partial intact flooding of the main engine and forward compartments. The actual passenger loading condition at the time of the accident is used as a baseline condition. The effect of transverse movement of the passenger loading is also analyzed.

Appendix A provides a general description of how curves of righting arm vs. angle of heel are developed and the significance of calculated righting energy vs. the various loading conditions. The Appendix also discusses the significance of righting energy in maintaining vessel stability to account for the variability in environmental conditions and other factors affecting stability.

VESSEL PARTICULARS

Owner	Shoreline Cruises, Lake George, NY
Built	1964, The Anchorage, Warren, RI
Model	Dyer 40
Hull No.	7
LOA	39.5 ft
LBP	33.5 ft
Beam	12.4 ft (molded, at MS)
Depth	5.93 ft (molded, at MS)

Table 1, VESSEL PARTICULARS

DESCRIPTION OF COMPUTER MODEL

A computer model of the vessel was created using Herbert Engineering Corporation's hydrostatic software package, HECSALV Version 7.6.6. This model includes hull offsets and hydrostatic properties, compartments and subdivision, and weights and centers. Hull offsets were obtained by laser measurement of the ETHAN ALLEN. Details of the HECSALV model are contained in Ref. 1.

ASSUMPTIONS

Unless otherwise noted, the following assumptions apply to this analysis.

1. The transverse bulkheads at the forward and aft ends of the engine room are considered watertight.
2. The flooded compartments are considered intact. Flooding is from an unspecified source.
3. Flooding is not considered to be constrained by the longitudinal stringers. This reflects either the existence of limber holes or water spilling from one side to the other as a result of vessel motion or heel. The source of the flooding is not a factor since the water will be free to settle in the lowest part of the compartment.
4. The vessel is operating in fresh water. All flood water is also fresh (62.4 lb/ft^3).
5. The fuel tank is 75% full.
6. The free surface correction is calculated directly using the moment transference method.
7. The passenger VCG is approximately 2 feet above the main deck.

8. Heel to port and trim forward are negative by convention throughout this report.
9. The 2005 Wood Canopy lightship condition is used for this analysis. A summary of the vessel lightship condition is presented in Table 2.

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	0.0	---	---	---	---	
Misc. Tanks	0.0	---	---	---	---	
Misc. Weights	0.0	---	---	---	---	
Displacement	14,689.0	5.29	2.71A	0.00	0.0	
Stability Calculation			**Trim Calculation**			
KMt	8.72	ft	LCF Draft		2.44	ft
VCG	5.29	ft	LCB		2.74A	ft-MS
GMt (Solid)	3.43	ft	LCF		4.18A	ft-MS
FSc	0.00	ft	MT1in		1.28	ft-LT/in
GMt (Corrected)	3.43	ft	Trim		0.31	ft-A
			List		0.0	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.56	ft				
Draft at M.S.	2.40	ft				
Draft at F.P.	2.25	ft				
Draft at Aft Marks	2.56	ft				
Draft at Mid Marks	2.40	ft				
Draft at Fwd Marks	2.24	ft				

Table 2, LIGHTSHIP CHARACTERISTICS

RESULTS

Passenger seating is arranged with 8 rows of bench seats. Each row has a three person bench on the port side and a two person bench on the starboard side. The aisle between them is slightly to starboard of centerline. Three additional 3-person benches are at the forward end of the vessel, symmetrical on the centerline. The vessel operator station is aft on the starboard side. This provides for a total of 49 passenger seats and one crew seat. At the time of the accident there were 47 passengers and one crew member on board. The total weight of passengers and crew was 8,522 lbs. Excluding the crew member, the average weight per passenger is 177.7 lbs. The actual passenger location and weight was provided by NTSB and is included in Appendix B. Figure 1 shows the actual passenger arrangement that is used for the flooding cases presented below. The results show that the total passenger (and crew) transverse center of gravity was 0.2 feet to port of centerline and the longitudinal center of gravity was 0.36 feet forward of midship. This created a 2.2 degree heel to port and 0.71 foot trim forward (see Figure 2, DEPARTURE LOAD CASE).

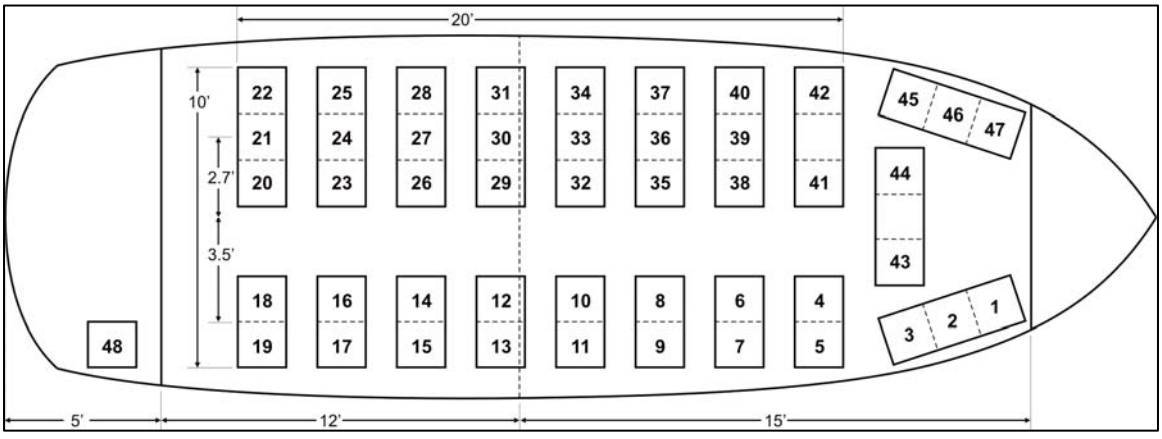

Figure 1, PASSENGER ARRANGEMENT

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4/21/2006

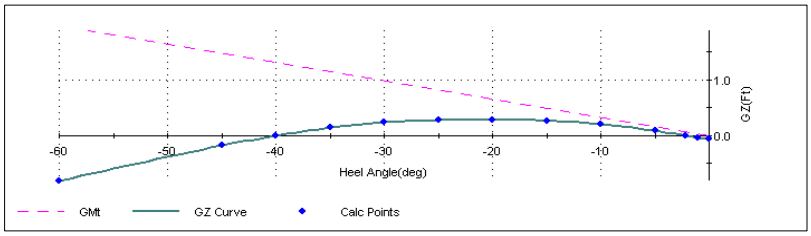
Intact Trim and Stability Summary
departure 47 pax, 1 crew

DEPARTURE CASE

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs
Light Ship	14,689.0	5.29	2.71A	0.00	----
Constant	0.0	0.00	0.00	0.00	0.0
Fuel Oil	526.5	2.27	1.34F	0.01P	88.1
Misc. Tanks	0.0	----	----	----	----
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0
Displacement	23,737.5	5.91	1.52A	0.07P	88.1

Stability Calculation			**Trim Calculation**		
KMt	7.80	ft	LCF Draft	2.97	ft
VCG	5.91	ft	LCB	1.44A	ft-MS
GMt (Solid)	1.89	ft	LCF	3.25A	ft-MS
FSc	0.00	ft	MT1in	1.60	ft-LT/in
GMt (Corrected)	1.88	ft	Trim	0.71	ft-F
			List	2.2P	deg
Specific Gravity	1.0				
Hull calcs from offsets			Tank calcs from offsets		
GM from GZ curve slope					

Drafts		
Draft at A.P.	2.68	ft
Draft at M.S.	3.04	ft
Draft at F.P.	3.39	ft
Draft at Aft Marks	2.67	ft
Draft at Mid Marks	3.04	ft
Draft at Fwd Marks	3.40	ft



Parameter	Units	Available
Angle of Heel	**deg**	2.2P
Angle at Maximum GZ	**deg**	19.6P
Area to 19.6 deg	**ft-deg**	3.44
Maximum GZ	**ft**	0.28
Range of Positive GZ	**deg**	37.6

Figure 2, DEPARTURE LOAD CASE

Beginning with the passenger arrangement shown in Figure 1, JMS analyzed the effects on intact stability for progressive amounts of partial internal flooding of 1. the engine compartment and 2. the forward compartment taking into account obstructions such as the main engine and fuel tank. Metacentric height and the righting arm curve for each level of flooding are provided in Appendices C and D. A summary of the cases is provided in Tables 3 and 4. Flooding levels are expressed both in terms of depth of water in the flooded space as well as total volume of water in the space. The depth of the water is derived from the tank table innage which assumes an even heel/trim condition (see Appendix E). There are several factors influencing the vessel's stability characteristics. The flooding adds weight low in the vessel, improving its stability, however, the loose water creates a free surface effect reducing the righting arm and increasing the heel. The effect is more pronounced with flooding in the engine compartment where a larger heeling arm can be developed than in the narrower forward compartment.

		0 gal	100 gal	200 gal	400 gal	600 gal	800 gal	1,000 gal	1,200 gal	1,450 gal
		0 in	19.3 in	22.9 in	27.3 in	30.7 in	33.7 in	36.6 in	39.4 in	42.7 in
Intact Weight Total	lbs	23,737.5	24,572.0	25,406.6	27,075.7	28,744.7	30,413.8	32,082.9	33,752.0	35,838.3
Fuel	lbs	526.5	526.5	526.5	526.5	526.5	526.5	526.5	526.5	526.5
Engine Compartment	lbs	-	834.5	1,669.1	3,338.2	5,007.2	6,676.3	8,345.4	10,014.5	12,100.8
Forward Compartment	lbs	-	-	-	-	-	-	-	-	-
Draft AP	ft	2.68	2.75	2.82	2.98	3.15	3.30	3.46	3.61	3.80
Draft FP	ft	3.39	3.40	3.41	3.39	3.34	3.28	3.21	3.13	3.07
Trim at Perpendiculars	ft	-0.71	-0.65	-0.59	-0.41	-0.20	0.02	0.25	0.47	0.73
Static Heel	deg	-2.2	-2.1	-2.3	-3.5	-6.0	-9.5	-13.2	-16.4	-18.1
GMt Uncorrected	ft	1.89	2.00	2.08	2.19	2.25	2.27	2.27	2.25	2.20
GMt Free Surf Corr	ft	0.00	0.11	0.41	1.12	1.66	1.96	2.11	2.18	2.19
GMt	ft	1.88	1.88	1.67	1.07	0.60	0.34	0.21	0.14	0.10
Angle at Max GZ	deg	19.6P	17.9P	18.4P	22.8P	24.2P	24.3P	23.4P	21.7P	19.7P
Area to Angle at Max GZ	ft-deg	3.44	2.89	2.72	2.45	1.75	1.00	.046	0.13	0.01
Maximum GZ	ft	0.28	0.27	0.24	0.18	0.15	0.11	0.07	0.04	0.00
Range of Positive GZ	deg	37.60	36.1	34.6	31.8	27.9	22.6	16.3	9.9	3.0

Table 3, ENGINE COMPARTMENT FLOODING SUMMARY

		0 gal	100 gal	200 gal	400 gal	600 gal	800 gal	1,000 gal	1,200 gal	1,450 gal
		0 in	12.4 in	16.1 in	21.0 in	25.0 in	28.5 in	31.7 in	34.5 in	37.9 in
Intact Weight Total	lbs	23,737.5	24,571.7	25,405.8	27,074.2	28,742.5	30,410.8	32,079.2	33,747.5	35,832.9
Fuel	lbs	526.5	526.5	526.5	526.5	526.5	526.5	526.5	526.5	526.5
Engine Compartment	lbs	-	-	-	-	-	-	-	-	-
Forward Compartment	lbs	-	834.2	1,668.3	3,336.7	5,005.0	6,673.3	8,341.7	10,010.0	12,095.4
Draft AP	ft	2.68	2.66	2.64	2.60	2.56	2.51	2.46	2.42	2.36
Draft FP	ft	3.39	3.53	3.67	3.94	4.22	4.49	4.75	5.01	5.33
Trim at Perpendiculars	ft	-0.71	-0.87	-1.03	-1.34	-1.66	-1.98	-2.29	-2.60	-2.97
Static Heel	deg	-2.2	-2.1	-2.0	-2.1	-2.2	-2.3	-2.4	-2.6	-2.7
GMt Uncorrected	ft	1.89	1.99	2.06	2.17	2.23	2.26	2.28	2.29	2.29
GMt Free Surf Corr	ft	0.00	0.04	0.15	0.43	0.66	0.86	1.02	1.14	1.26
GMt	ft	1.88	1.94	1.19	1.75	1.57	1.40	1.26	1.15	1.03
Angle at Max GZ	deg	19.6P	19.4P	20.3P	22.3P	22.5P	21.7P	20.6P	19.1P	16.7P
Area to Angle at Max GZ	ft-deg	3.44	3.70	3.94	4.23	3.89	3.29	2.75	2.28	1.45
Maximum GZ	ft	0.28	0.30	0.30	0.29	0.27	0.29	0.23	0.20	0.16
Range of Positive GZ	deg	37.60	36.5	36.0	35.7	34.9	33.8	32.1	29.8	26.0

Table 4, FORWARD COMPARTMENT FLOODING SUMMARY

The effect of transverse movement of the passenger load was also analyzed. A passenger (and crew) transverse center of gravity of 0, -0.2 feet, -0.4 feet, -0.6 feet, -0.8 feet, and -1.0 feet are compared (see Table 5). The transverse weight shift has no effect on metacentric height (GM) but it does increase heel and reduce the righting arm. In this case, the righting arm disappears with the passenger weight shifted 1.0 feet off centerline (or 0.8 feet from the initial loading condition). Detailed results are presented in Appendix E.

		TRANSVERSE CENTER OF PASSENGER WEIGHT FROM CENTERLINE					
		TCG 0.0 ft	**TCG -0.2 ft (reported pax loading)**	**TCG -0.4 ft**	**TCG -0.6 ft**	**TCG -0.8 ft**	**TCG -1.0 ft**
Intact Weight Total	lbs	23,737.5	23,737.5	23,737.5	23,737.5	23,737.5	23,737.5
Pax/Crew Weight	lbs	8,522.0	8,522.0	8,522.0	8,522.0	8,522.0	8,522.0
Pax/Crew VCG	ft abv BL	7.21	7.21	7.21	7.21	7.21	7.21
Pax/Crew LCG	ft fwd of AP	17.12	17.12	17.12	17.12	17.12	17.12
Fuel	lbs	526.5	526.5	526.5	526.5	526.5	526.5
Draft AP	ft	2.69	2.68	2.67	2.65	2.60	2.44
Draft FP	ft	3.39	3.39	3.39	3.38	3.37	3.36
Trim at Perpendiculars	ft	-0.70	-0.71	-0.71	-0.73	-0.77	-0.92
Static Heel	deg	0.0	-2.2	-4.5	-7.1	-10.5	-16.8
GMt Uncorrected	ft	1.89	1.89	1.89	1.89	1.89	1.89
GMt Free Surf Corr	ft	0.00	0.00	0.00	0.00	0.00	0.00
GMt	ft	1.88	1.89	1.89	1.89	1.88	1.88
Angle at Max GZ	deg	19.2	19.6P	19.9P	20.3P	20.7P	21.4P
Area to Angle at Max GZ	ft-deg	4.77	3.44	2.28	1.43	0.58	0.04
Maximum GZ	ft	0.35	0.28	0.21	0.15	0.08	0.01
Range of Positive GZ	deg	41.4	37.6	33.5	28.8	22.7	11.1

Table 5, TRANSVERSE CENTER OF PASSENGER WEIGHT

APPENDIX A

TRANSEVERSE STABILITY

EXCERPT FROM *MARINE CASUALTY RESPONSE: SALVAGE ENGINEERING*

JMS NAVAL ARCHITECTS & SALVAGE ENGINEERS AND THE AMERICAN SOCIETY OF NAVAL ENGINEERS, 1999

1-5 TRANSVERSE STABILITY

Transverse stability is the measure of a ship's ability to resist rotation about its longitudinal axis and return to an upright position after being disturbed by an upsetting force. The following paragraphs define the elements of transverse stability and provide methods to calculate the transverse stability characteristics of a vessel.

1-5.1 Equilibrium and Stability. A ship floating at rest, with or without list and trim, is in static equilibrium; that is, the forces of gravity and buoyancy are equal and acting in opposite directions in line with one another. Stability is the tendency of a ship to return to its original position when disturbed after the disturbing force is removed. Stability can be described as positive, negative, or neutral.

1-5.2 Internal Forces. The internal forces affecting floating bodies are the forces of gravity and buoyancy. Both of these forces act at all times on wholly or partially submerged bodies. Figure 1-13 illustrates the relationship between the forces of buoyancy and gravity. Assuming the prism floats with half its volume submerged, and with the center of gravity located as shown, the prism can come to rest in either position (a), with the center of gravity directly above the center of buoyancy, or (c), with the center of buoyancy above the center of gravity. In either position, the forces of buoyancy and gravity act along the same vertical line. If the prism is inclined from (a) to (b), or from (c) to (d), a couple, or righting moment, is developed between the lines of action of buoyancy and gravity that tends to move the body back to its original position, i.e., the body floats with positive stability in either position. In position (a), with the center of gravity above the center of buoyancy, stability is provided by the body's shape, or form, and is termed *form stability*. If the width of the prism is reduced while the center of gravity remains on the centerline at the same location, a situation arises in which the center of buoyancy does not move far enough to be to the right of the center of gravity as the body is inclined from (a) to (b). The body can then attain positive stability only in position (c), with the center of buoyancy above the center of gravity. Bodies floating with the center of buoyancy above the center of gravity develop positive initial righting moments regardless of shape. This mode of stability is called *weight stability*. Sailing yachts with deep weighted keels, spar buoys, conventional ships with very low centers of gravity, and submarines all exhibit weight stability. Capsized ships floating upside down very often have their centers of gravity below the center of buoyancy, and operate in a weight stability mode.

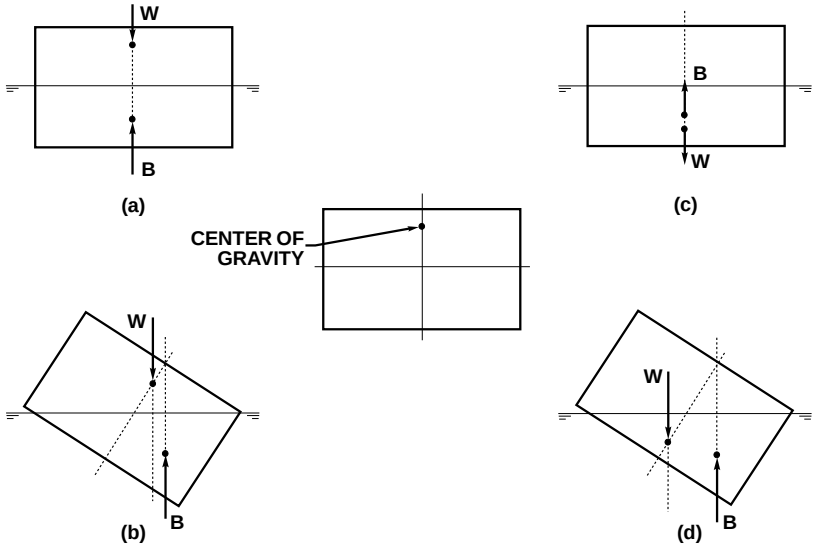


Figure 1-13. Stability of a Floating Object.

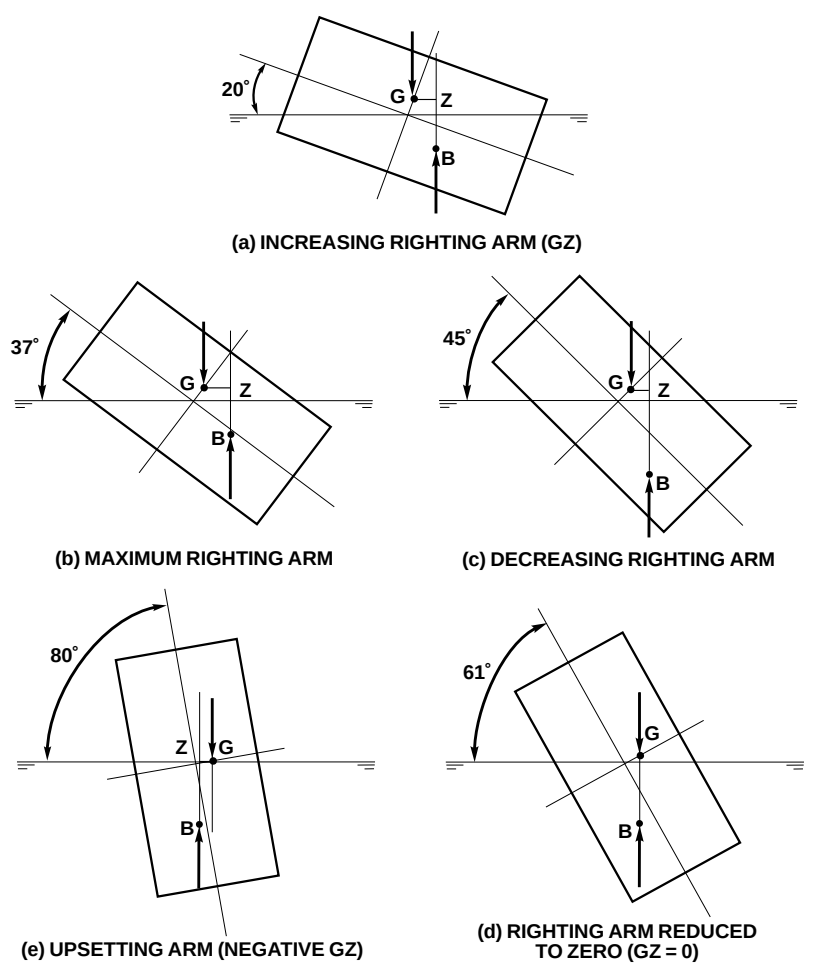


Figure 1-14. Development and Loss of Righting Arm.

The center of buoyancy of a ship moves as the ship is inclined, in a manner that depends on the shape of the hull near the waterline. The center of buoyancy initially moves away from the centerline as the ship is inclined, as shown in Figure 1-14. At some angle of inclination, the center of buoyancy begins to move back towards a vertical reference line drawn through the original position of the center of buoyancy. The vertical line of action of the center of gravity continues to move outward as the ship is inclined. At some angle of inclination, the line of action of gravity moves outboard of the line of action of buoyancy, creating an upsetting moment. Ships that have slowly heeled through progressively greater angles of inclination will suddenly capsize when this angle of zero righting moment (angle of vanishing stability) is passed.

In Figure 1-15, the prism is assumed to be neutrally buoyant so that it is wholly submerged but clear of the bottom. An inclination from (a) produces an upsetting moment that tends to rotate the prism away from its initial position. Conversely, a inclination from (c) produces a righting moment. A submerged object clear of the bottom or other restraints can therefore have positive stability in only one position, that is, with the center of buoyancy above the center of gravity. Submerged objects therefore operate in a weight stability mode. The difference in behavior of floating and submerged objects is due to the fact that the center of buoyancy of a submerged object is fixed at the center of volume of the object, while the center of buoyancy of a floating object will generally shift when the object is inclined. Because the center of buoyancy of a submerged object is fixed, the righting moment cannot change to an upsetting moment as the object inclines unless the position of the center of gravity shifts. Stability of submarines and other submerged objects is discussed more completely in the *U.S. Navy Ship Salvage Manual, Volume 4* (S0300-A6-MAN-040).

Figure 1-16 shows how a stable ship subjected to normal disturbances will develop moments tending to return the ship to its original position. A couple is formed as the lines of action of the opposing forces of gravity and buoyancy are separated. The arm of this couple, called the *righting arm*, is the lever to which the ship's weight is applied to right the ship. Figure 1-17 shows the *upsetting arm* developed when unstable ships are disturbed.

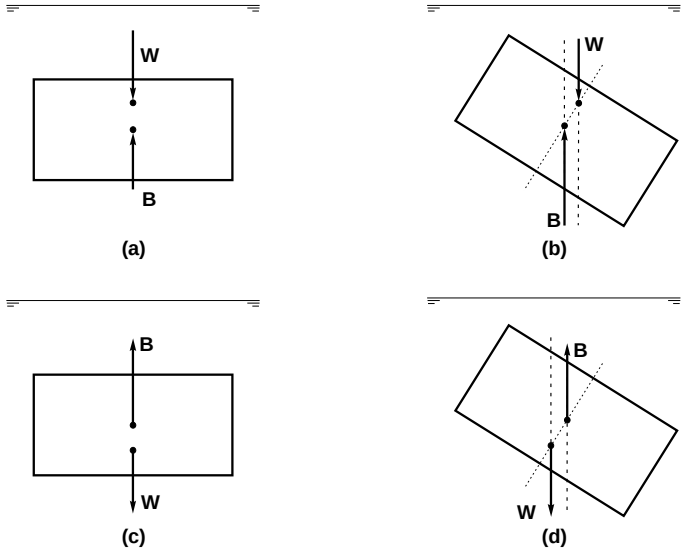


Figure 1-15. Stability of a Submerged Object.

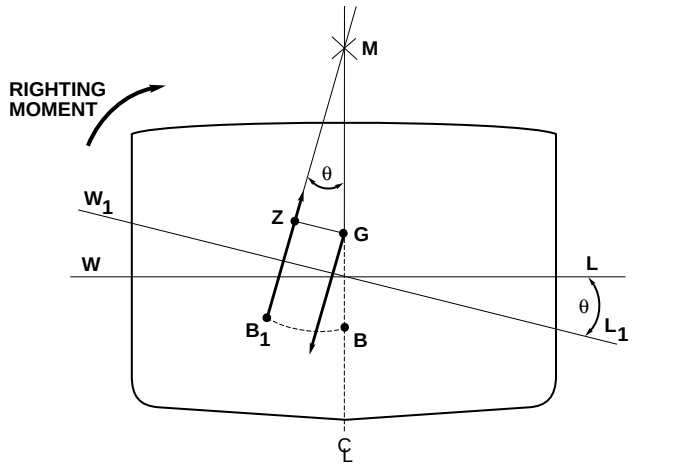


Figure 1-16. Righting Arm (GZ).

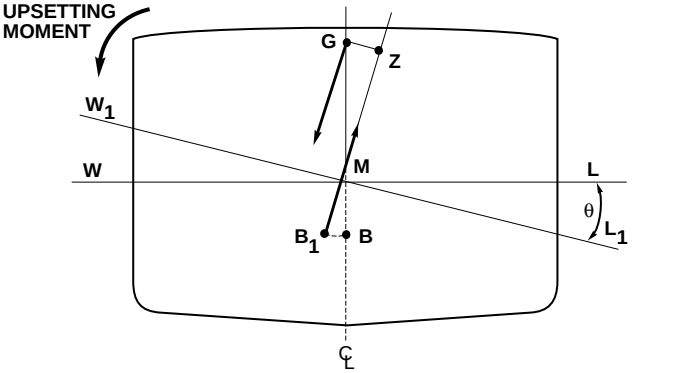


Figure 1-17. Upsetting Arm.

1-5.3 External Forces. Ships are inclined by various external forces:

- Wave action,
- Wind,
- Collision,
- Grounding,
- Shifting of onboard weights, and
- Addition or removal of weight.

Any inclination of a ship can be termed *heel*, but inclinations are broadly defined as *heel*, *list*, or *roll* depending on the duration and nature of the forces causing the inclination.

- ***Heel*** – The term heel is specifically applied to noncyclic, transient inclinations caused by forces that may be removed or reversed quickly. Such forces include wind pressure, centrifugal force in high-speed turns, large movable weights, etc.
- ***List*** – A list is a permanent, or long-term inclination, caused by forces such as grounding or offcenter weight that are not likely to be removed suddenly.
- ***Roll*** – When an inclining force is suddenly removed, a ship does not simply return to its upright position, but inclines to the opposite side and oscillates, or rolls, about its equilibrium position for some time before coming to rest. The natural rolling period (period of roll assumed by a ship free of restraints and exciting forces) is a function of weight and buoyancy distribution. Rolling is cyclic in nature and is induced or aggravated by short duration, repetitive or cyclic forces, such as wave forces.

1-5.4 Heights of Centers. The relative heights of the centers of gravity and buoyancy and the metacenter govern the magnitude and sense of the moment arms developed as the ship inclines. They are, therefore, the primary indicators of a ship's initial stability. Nominally, the symbols *KG*, *KB*, and *KM* indicate the heights of the centers of gravity and buoyancy and the metacenter above the *bottom of the keel*, while the symbols *VCG* and *VCB* indicate the vertical positions of the centers of gravity and buoyancy, measured from the *baseline.* In practice, *KG*/*KB* and *VCG*/*VCB* are used almost interchangeably; in steel ships with flat plate keels, the difference in height above baseline and keel for any point is generally less than two inches and is not significant.

1-5.4.1 Height of the Center of Gravity. The height or vertical position of the center of gravity above the keel (*KG* or *VCG*) is defined by weight distribution. *KG* can be varied considerably without change of displacement by shifting weight up or down in the ship. Conversely, it is possible to add or remove weight without altering *KG*. In most ships, the center of gravity lies between six-tenths of the depth above the keel and the main deck:

$$0.6D < KG < D$$

where:

D = hull depth, keel to main deck

For barges with raked or ship-shaped bows and cut-up sterns, lightship *KG* can be estimated as 0.53D. For tank barges, *KG* for full load varies little from the lightship value.

Table 1-4 gives very approximate values for the height of the center of gravity for several types of merchant ships at *lightship*, and for some naval ship types at *full load*. Calculation of *KG* can be a laborious and time-consuming process, but ignorance of the height of a ship's center of gravity invites disaster. If the height of the ship's center of gravity is known for any condition of loading (lightship, for example), and the location of added or removed weights is known, the new height of the center of gravity can be calculated':

$$KG_{new} = \frac{W_{old} KG_{old} + \Sigma w(kg)}{W_{old} + \Sigma w}$$

where:

KG = height of the ship's center of gravity, G, above the keel
W = total weight of the ship and contents
w = individual weights added (+) or removed (-)
kg = height above keel of centers of gravity of added or removed weights, w

Table 1-4. Approximate *KG*.

Ship Type	***KG*** **(*D* = depth at midships)**
Merchantmen (*KG* at lightship)[1]:	
Dry Cargo	0.68*D*
Passenger/Cargo	0.75D
Insulated Cargo	0.72*D*
Cross-Channel	0.68D
Oil Tanker	0.69*D*
Naval ships (*KG* at full load)[2]:	
Cruiser/Destroyer	0.55*D*
Frigate	0.61*D*
Amphibious Warfare without well decks (LST/LKA/LPH)	0.63*D*
Amphibious Warfare with well decks (LSD/LPD/LHA/LHD)	0.72*D*
Fleet replenishment (AE/AOE/AOR/AFS/AO)	0.62*D*
Tender/Repair Ship	0.5*D*

Source:
[1] *Applied Naval Architecture,* R. Munro-Smith, 1967
[2] Jamestown Marine Services, 1990

Height of the center of gravity of cargo can generally be obtained from the ship's officers, usually the chief mate. In the absence of better information, the design estimations proposed by R. Munro-Smith (*Applied Naval Architecture,* 1967) shown in Table 1-5 may be helpful.

Table 1-5. Approximate *KG* of Cargo in Full Holds.

Hold/Space	*KG* of Cargo (*D* = depth of hold)
No. 1	0.7*D* + depth of double bottom
No. 2	0.7*D* + depth of double bottom
No. 3	0.7*D* + depth of double bottom
No. 4	0.7*D* + depth of double bottom
No. 5	0.7*D* + depth of double bottom
'tween decks	height above keel to half depth of 'tween deck at mid length of the space

Based on full holds (homogeneous cargo) in general cargo ship with machinery amidships, three holds forward and two aft. In ships with extensive parallel midbody, it may be more appropriate to apply the expression for hold No. 3 to all holds in the parallel midbody, with the expression for No. 1 or No. 2 (depending on fineness of forebody) applied to the forward most hold. A similar analysis should be applied to holds aft of the machinery space, if any.

1-5.4.2 Height of the Center of Buoyancy. The height of the center of buoyancy above the keel (*KB*) is solely a function of the shape of the underwater volume. As the centroid of the underwater hull, the center of buoyancy is lower in flat-bottomed, full-bodied ships, such as tankers and ore carriers, than in finer lined ships like destroyers or frigates. Disregarding changes in the shape of the immersed hull due to trim and heel, *KB* of any ship is a function of displacement, and therefore of draft. The height of the center of buoyancy can be calculated by summing incremental waterplane areas (a_{WP}) multiplied by their heights above the keel (z) and dividing the result by the displacement volume (∇):

$$KB = \frac{1}{\nabla}\int a_{wp} z \; dz$$

This expression can be evaluated by numerical integration methods if accurate drawings or offsets are available. In practice, *KB* can be approximated with sufficient accuracy for salvage work as 0.52*T* for full-bodied ships and 0.58*T* for fine-lined ships. At very light drafts, *KB* is closer to the given waterline because the lower waterlines are usually much finer than the waterlines in the normal draft range. As a vessel's underwater hull form approaches a rectangular prism (C_B = 1.0), *KB* approaches 0.5*T*. The following empirical relationships give estimates for *KB* that are very close to calculated values for merchant vessels of ordinary form at normal drafts:

$$KB = \frac{1}{3}\left(\frac{5T}{2} - \frac{\nabla}{A_{WP}}\right) \qquad \text{(Morrish's Formula)}$$

$$KB = T_m \frac{A_{WP}}{A_{WP} + \frac{\nabla}{T_m}} \qquad \text{(Posdunine's Formula)}$$

where:

T_m = mean draft, [length]
∇ = displacement volume, [length^3]
A_{WP} = waterplane area, [length^2]

1-5.4.3 Metacentric Height. The *transverse metacentric height* (GM_T), commonly called the *metacentric height*, of a ship is the vertical separation of the center of gravity and the transverse metacenter (see Figure 1-4) and is a primary indicator of initial stability. A ship with a positive metacentric height (*G* below *M*) will tend to right itself by developing righting arms as soon as an inclining force is applied. A ship with a negative metacentric height (*G* above *M*) will list to either port or starboard with equal facility until the centers of buoyancy and gravity are on the same vertical line, and thereafter develop positive righting arms. This condition, known as *lolling*, is a serious symptom of impaired initial stability. Metacentric height is calculated by subtracting the height of the center of gravity from the height of the metacenter above the keel:

$$GM_T = KM_T - KG$$

Transverse Metacentric Radius. The transverse metacentric radius (BM_T) is the vertical distance between the center of buoyancy and the metacenter. This distance is termed a radius because for small heel angles, the locus of successive centers of buoyancy approximates a circular arc, with the transverse metacenter as its center. Metacentric radius is equal to the moment of inertia of the waterplane about its longitudinal centerline (*transverse moment of inertia*, I_T) divided by the underwater volume of the hull (∇):

$$BM_T = \frac{I_T}{\nabla}$$

For a rectangular waterplane, $I_T = LB^3/12$, $\nabla = LBT$ and:

$$BM_T = \frac{I_T}{\nabla} = \frac{\frac{LB^3}{12}}{LBT}$$

$$= \frac{B^2}{12T}$$

where:

L = length between perpendiculars, [length]
B = beam, [length]
T = mean draft, [length]

If the waterplane shape can be accurately defined, the moment of inertia can be determined by numerical integration. If not, the transverse moment of inertia of most ships' waterplanes can be approximated by:

$$I_T \approx C_{IT} LB^3$$

where C_{IT} is the transverse inertia coefficient and is approximated by $C_{WP}^2/11.7$ or $0.125C_{WP} - 0.045$. These expressions for transverse inertia coefficient are derived from the analysis of numerous ships, and are reasonable approximations for use in salvage for ships with $C_{WP} < 0.9$. For ships with $C_{WP} > 0.9$, $LB^3/12$ is a closer approximation of the transverse moment of inertia of the waterplane.

Height of the Metacenter. The height of the metacenter above the keel is calculated by adding the metacentric radius to the height of the center of buoyancy above the keel:

$$KM = KB + BM$$

$$\therefore \quad GM = KB + BM - KG$$

When denoting transverse metacenter, *BM*, *KM*, and *GM*, the subscript "T" is often omitted as understood.

Ships with large *GM* develop large initial righting arms and therefore respond to moderate disturbing forces with sharp, short-period rolling. These ships are said to be *stiff*. Ships with smaller metacentric heights develop smaller initial righting arms and roll more gently in a seaway. Ships with small metacentric heights are said to be *tender*. Insufficient initial stability results in constant rolling in even gentle seas, making work difficult, and may allow extreme rolling in heavier seas, perhaps causing the ship to take on water or capsize. Excessive initial stability, or stiffness, is also undesirable because it produces an uncomfortable ride, reduces personnel effectiveness, increases requirements on weapons stabilization systems, increases lateral acceleration loads on topside cargo and equipment, and increases hull stresses. These matters usually do not concern the salvage engineer, but very stiff rolling of a casualty under tow may damage sensitive equipment, loosen patches, or place excessive loads on damaged structure. The term *seakindly* is used to describe a ship whose metacentric height is great enough to give adequate stability, but not large enough to cause excessive stiffness.

The natural rolling period is a function of weight and buoyancy distribution and can be expressed as a function of *GM* and transverse radius of gyration (*k*):

$$T_R = \frac{2\pi k}{\sqrt{gGM}}$$

where:

T_R = natural rolling period, seconds
k = transverse radius of gyration of the ship mass, [length]
= 0.4 to 0.5 times the beam, depending on depth and transverse weight distribution
GM = transverse metacentric height, [length]
g = acceleration due to gravity, [length/sec^2]

If *GM* and *k* are expressed in feet, and *g* is taken as 32.174 ft/sec^2, the rolling period formula reduces to:

$$T_R = \frac{1.108k}{\sqrt{GM}}$$

and:

$$GM = \left(1.108\frac{k}{T_R}\right)^2$$

If the natural rolling period is known, *GM* can be estimated. Taking radius of gyration *k* as beam (*B*) multiplied by a coefficient (*C*), a conservative estimate of *GM* can be made:

$$GM \approx \left(\frac{CB}{T_R}\right)^2$$

The coefficient *C* can be taken as 0.4 to 0.5 for naval surface ships (0.44 average), 0.4 to 0.45 for submarine hulls based on bodies of revolution, and 0.32 to 0.37 for other submarines. *Ships and Marine Engines, Volume IV, The Design of Merchant Ships* (Schokker et al, 1953) gives some experimentally derived values for commercial vessels: 0.425 for large cargo and passenger liners, 0.385 for smaller passenger liners, 0.390 for a loaded passenger liner, and 0.405 for an ore ship in ballast. This same text references Laursen's possibly more correct approach of expressing radius of gyration as a function of both beam and depth:

$$k = C\sqrt{B^2 + D^2}$$

where the constant *C* ranges from 0.35 to 0.39 for cargo ships of ordinary form.

The rolling period formula will not give an accurate estimate of *GM* for a ship rolling in a seaway because the rolling period is modified by wave and wind forces. Significant changes in *GM* will be reflected by marked changes in rolling period; increased rolling period is a sign of deteriorating stability. An empirically derived relationship holds that stability is adequate when:

$$T_R \leq 2\sqrt{B}$$

where:

B = beam, ft

1-5.5 Righting Arm. At equilibrium, the forces of gravity and buoyancy act equally in opposition along the vertical centerline. As the center of buoyancy shifts with a heel, the two opposing forces act along separate and parallel lines. The forces establish the couple which tends to return a stable ship to the upright position. The distance *GZ* between the lines of action of the center of gravity and the center of buoyancy, as shown in Figure 1-16, is the righting arm. The sine of the angle of inclination (θ) is the ratio of *GZ* to *GM*.

$$\sin\theta = \frac{GZ}{GM}$$

$$\therefore \quad GZ = GM \sin\theta$$

This relationship applies for heel angles so small that the waterplane shape is not appreciably changed, usually taken as less than 10 degrees for wall-sided ships and 7 degrees for fine-lined ships. At greater angles of heel, the metacenter moves away from the centerline and the relationship between *GZ* and *GM* no longer applies.

1-5.6 Righting Moment. The force applied to a righting arm (*GZ*) is the ship's weight. The righting moment (*RM*) developed at any angle of heel is given by:

$$RM = W \times GZ$$

At any angle of heel, the stability of the ship is measured by the righting moment developed. Since the righting moment is equal to the righting arm times displacement and displacement normally remains constant as the ship heels, the righting arm may also be used to measure stability for a given condition of loading. This assumption lends itself to the use of the cross curves of stability as discussed in Paragraph 1-5.9.

1-5.7 Change of Displacement. Any change of displacement will affect the righting moments developed by the ship. An increased displacement increases *W* in the expression $RM = W \times GZ$, but also affects *GZ* by:

- Increasing draft and thereby *KB*.
- Increasing ∇, thereby reducing *BM* as *I* will not change significantly ($BM = I/\nabla$).

The height of the metacenter is normally reduced as displacement increases because the increase in *KB* is usually less than the reduction in *BM*. The opposite effects will be noted when displacement is decreased. Additionally, the location of the added weight will affect the location of the center of gravity and therefore *GM* and *GZ*. These effects are simultaneous but not normally compensatory. The net effect of a change in displacement may be either an increase or a decrease in righting moments. In general, the addition of low weight or removal of high weight will increase stability, but each change of displacement must be carefully analyzed to determine its exact effect.

1-5.8 List. List, a long-term inclination of the ship to one side or the other, is caused by:

- Offcenter weight.
- Negative *GM*.
- A combination of offcenter weight and negative *GM*.

Before attempting to correct a list on a ship, the cause must be determined. Inappropriate corrective measures will only aggravate the situation.

A list caused by offcenter weight is identified by the ship's tendency to return to its listing condition when an external force is applied temporarily and then removed. A list caused by negative *GM* is identified by the ship's tendency to loll, or list to either side with equal facility, when disturbed. A list caused by a combination of offcenter weight and negative *GM* is identified by the ship's tendency to list with equal facility to either side, but with a greater degree of list to one side. Negative *GM* is the most serious condition that causes a list and should be corrected first. Paragraph 1-9.4 discusses the effects of negative *GM* in greater detail.

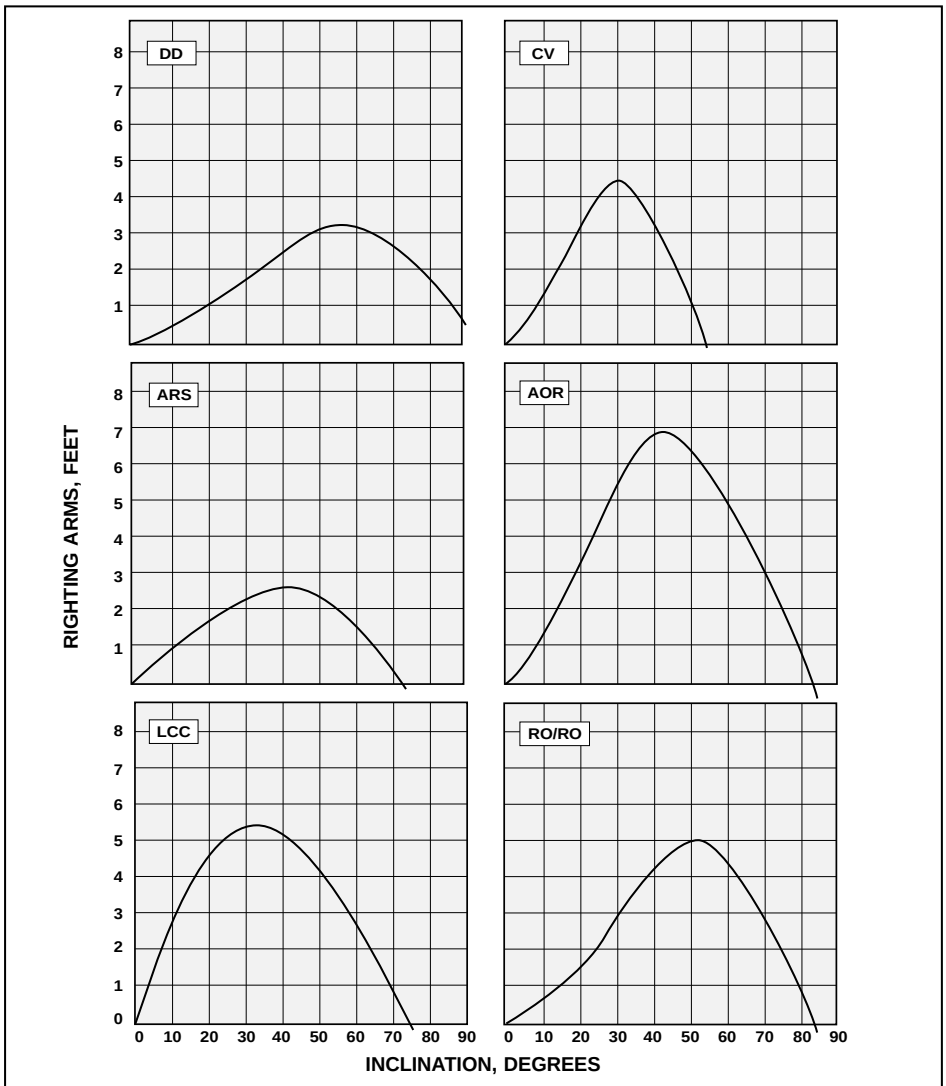


Figure 1-18. Typical Stability Curves.

1-5.9 The Stability Curve. The righting arm *GZ* is the distance between the lines of action of buoyancy and gravity at any angle of heel. Since the expression $GZ = GM \sin\theta$ cannot be used at larger angles of heel, the righting arm for a given heel angle is determined by accurately locating the centers of gravity and buoyancy, and measuring the separation between their lines of action. If movable weights within the ship can be neglected, the center of gravity can be assumed to be fixed. As the ship heels, the center of buoyancy will move to the new center of the underwater volume, which can be determined by numerical integration or graphical means. As a ship heels, it also changes its trim to some extent to maintain constant displacement. This small change in trim can usually be disregarded when calculating righting arms. Centers of buoyancy for various inclinations, and the resulting righting arms are determined by numerical integration. These computations can be shortened somewhat by the methods described in Paragraph 1-5.11. A plot of righting arm against heel angle is variously called a *curve of statical stability*, *stability curve*, *righting arm curve*, or *GZ curve*. Figure 1-18 shows typical stability curves for various ship types.

1-5.9.1 Cross Curves of Stability. As a ship's displacement is variable, the designers prepare stability curves for a range of displacements. It is customary to plot righting arm values against displacement for each of a number of angles of inclination to create a group of curves known as *cross curves of stability.* By entering the cross curves with the displacement of the ship and reading the righting arms for each angle of heel, a stability curve for any displacement can be developed. Since height of the center of gravity varies with loading, an assumed position of the center of gravity was used by the designer to develop the cross curves of stability. Once the stability curve has been corrected for the true location of the center of gravity, the following stability data can be obtained:

- Range of stability.
- Righting arm and moment at any angle of inclination.
- Maximum righting arm and moment.
- Angle of the maximum righting arm and moment.
- Metacentric height.
- Angle of deck edge immersion.

The following examples use the FFG-7 Class cross curves of stability from Figure 1-19 to develop the initial and corrected stability curves. Figure 1-20 is the stability curve as taken from the cross curves for a displacement of 3,200 tons.

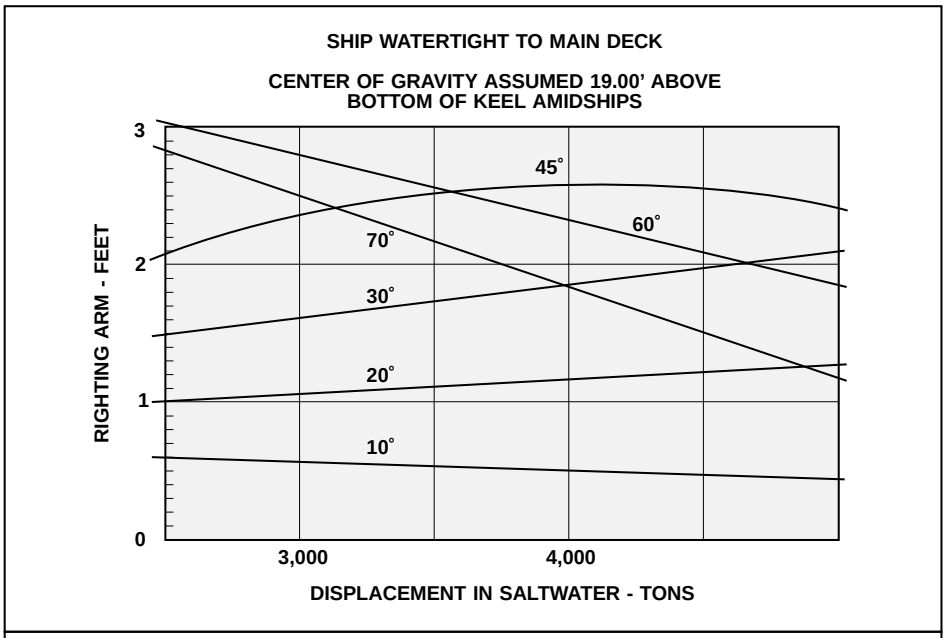


Figure 1-19. FFG-7 Class Cross Curves of Stability.

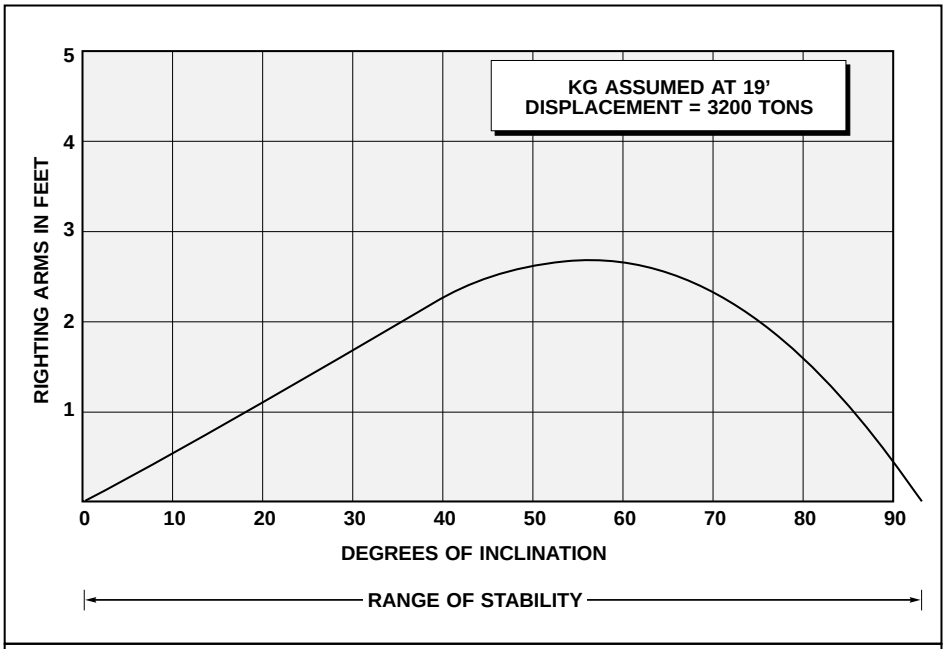


Figure 1-20. Statical Stability Curve.

1-5.9.2 Correction for Actual *KG*. If the actual center of gravity lies above the assumed center of gravity, the metacentric height is decreased and the ship is less stable; conversely, if the actual center of gravity is below the assumed center, the metacentric height is increased and the ship is more stable.

Figure 1-21 shows that the actual righting arm, G_nZ_n is equal to the assumed righting arm plus or minus the vertical distance between the actual and assumed *KG*, multiplied by the sine of the angle of heel:

$$G_nZ_n = GZ \pm GG_n \sin\theta$$

The actual, or corrected, stability curve can be constructed graphically as a sine curve correction.

The $GG_n \sin\theta$ curve is plotted to the same scale as the curve of statical stability as shown in Figure 1-22. The ordinates of the corrected curve are the differences between the ordinates of the two curves and can be picked off and plotted using dividers, as shown, or determined by tabular calculation.

If the actual height of the center of gravity is less than the assumed height, the correction curve is plotted below the horizontal axis.

The assumed *KG* is sometimes called *pole height*. It is a common practice, especially with European designers, to develop cross curves based on an assumed pole height of zero. Since the assumed position of the center of gravity coincides with the keel, the resulting cross curves are termed *KN* curves.

1-5.9.3 Range of Stability. The range of stability—the range of inclinations through The new stability curve is again the difference between the two curves.which the ship develops positive righting arms—is indicated by the intersections of the stability curve with the horizontal axis. For the corrected stability curve in Figure 1-22, the range of stability is from 0 to 75 degrees.

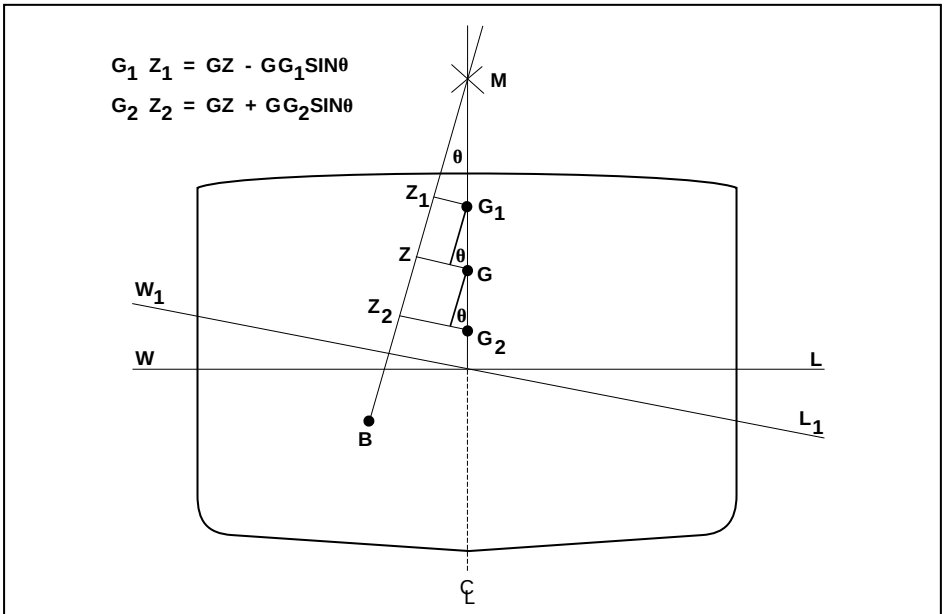


Figure 1-21. Assumed KG for Stability Curve.

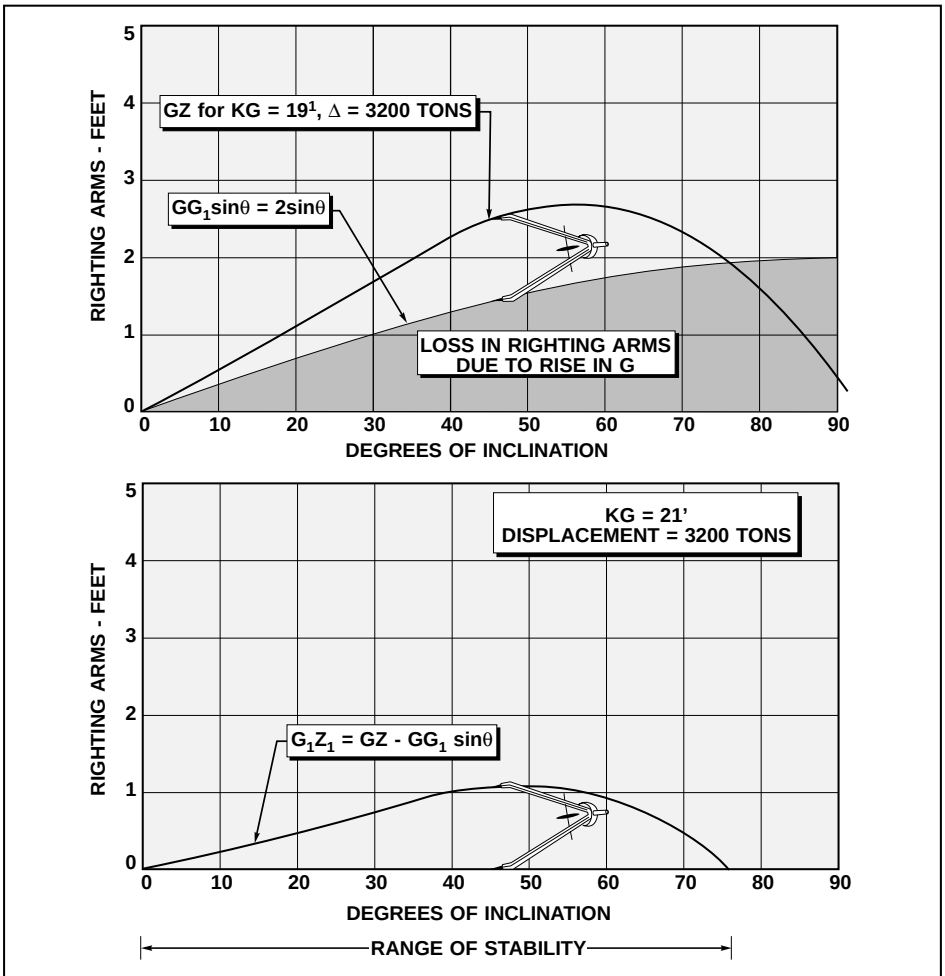


Figure 1-22. Correction to Stability Curve, G Two Feet Higher Than Assumed.

1-5.9.4 Righting Arm and Righting Moment. The righting arm at any inclination is read directly from the curve. Because each stability curve applies only to a specific displacement and *KG*, the righting moment can be obtained directly for any angle by multiplying the righting arm by the displacement. Maximum righting arm, maximum righting moment, and angle of maximum righting moment can be determined by inspection of the stability curve. From the corrected stability curve in Figure 1-22, maximum righting arm is approximately 1.1 feet at 51 degrees of inclination, giving a maximum righting moment of 3,520 foot-tons (1.1 ft × 3,200 tons). Maximum righting arm and the angle at which it occurs are important parameters when an upsetting moment is applied gradually or statically. Once the upsetting moment exceeds the maximum righting moment, the ship will list past the angle of maximum righting arm. If the upsetting moment is not immediately removed, the ship will capsize, because as the ship heels to progressively greater angles, righting moment, already less than the upsetting moment, will steadily decrease. However, ships can, and do, safely roll past their angle of maximum righting arm in response to short-term or cyclic upsetting forces.

1-5.9.5 Metacentric Height. *GM* is the measure of the slope of the *GZ* curve at the origin. The metacentric height is equal to the height of the intersection of a tangent to the statical stability curve at the origin with a perpendicular to the horizontal axis at 57.3 degrees (one radian). Although metacentric height can be approximated from a stability curve by this means, it is more common that *GM* is known and the intercept is sketched to help draw the initial part of the stability curve. The corrected stability curve in Figure 1-22 indicates a *GM* of approximately 1.2 feet.

1-5.9.6 Angle of Deck Edge Immersion. For most hull forms, an inflection point in the curve corresponds roughly to the angle of deck edge immersion. This point is not necessarily at or near the angle of maximum righting arm. The inflection results from the abrupt change in the shapes of the waterplane and underwater volume as the deck edge is immersed. The rate of increase in righting arm has changed from positive to negative—i.e., righting arms are still increasing, but at a slower rate. The angle of deck edge immersion varies along the length of the ship, but lies within a relatively narrow range for the large midbody sections that have the greatest influence on the stability curve. The stability curve in Figure 1-22 shows the angle of deck edge immersion to be about 38 degrees.

1-5.9.7 Righting Energy. The area under the stability curve, (foot-degrees, meter-radians), is a measure of the ship's dynamic stability—its ability to absorb energy imparted by winds, waves or other external forces. A ship with very little area (righting energy) under its stability curve could be rolled past its range of stability and capsized by even a momentary disturbance.

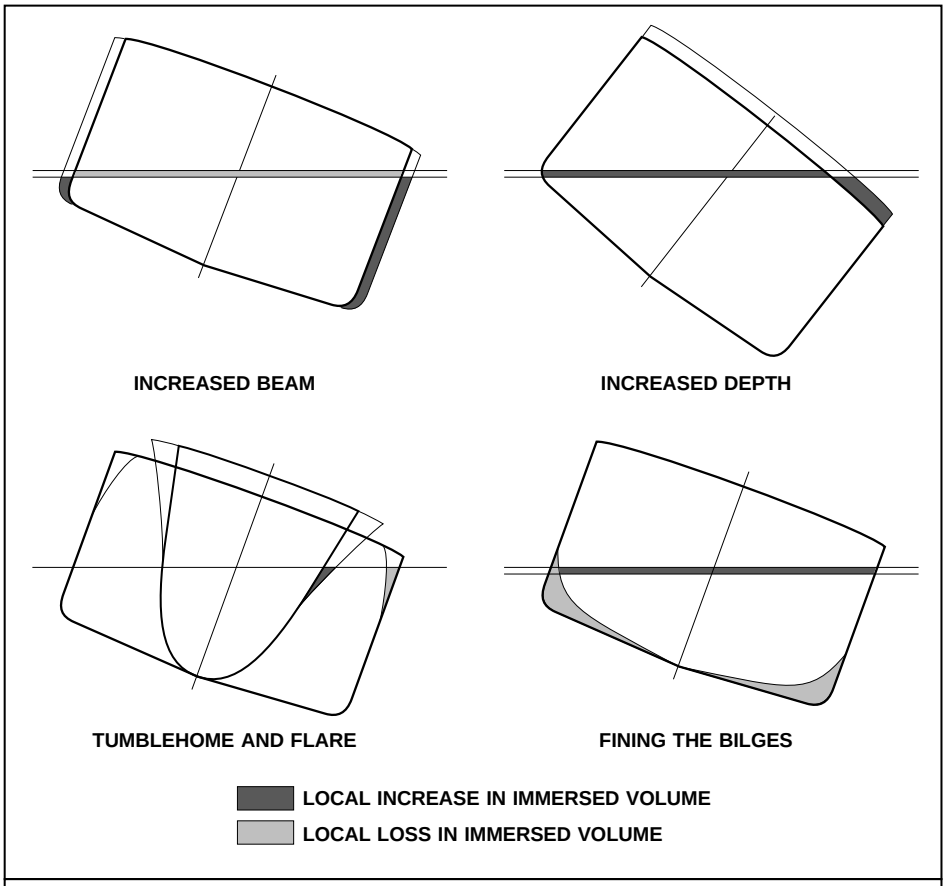


Figure 1-23. Effects of Changing Hull Form.

1-5.10 Effects of Hull Form on the Stability Curve. While initial stability (righting arms at small angles of heel) depends almost entirely on metacentric height, the overall shape of the stability curve is governed by hull form. Figure 1-23 shows how changing hull form increases or decreases righting arm by altering the position and movement of the center of buoyancy. Figure 1-24 (Page 1-40) illustrates how altering hull form affects the stability curve as described in the following paragraphs.

1-5.10.1 Beam. Of all the hull dimensions that can be varied by the designer, beam has the greatest influence on transverse stability. Metacentric radius (*BM*) was shown to be proportional to the ratio B^2/T in Paragraph 1-5.4.3. *BM*, and therefore *KM*, will increase if beam is increased while draft is held constant. If freeboard is held constant while beam is increased, the angle of deck edge immersion is decreased; righting arms at larger angles and the range of stability are reduced. If the depth remains constant, overall stability will be reduced because *KB* decreases, increasing *BG*, although this will be offset at small angles by the increase in *BM*.

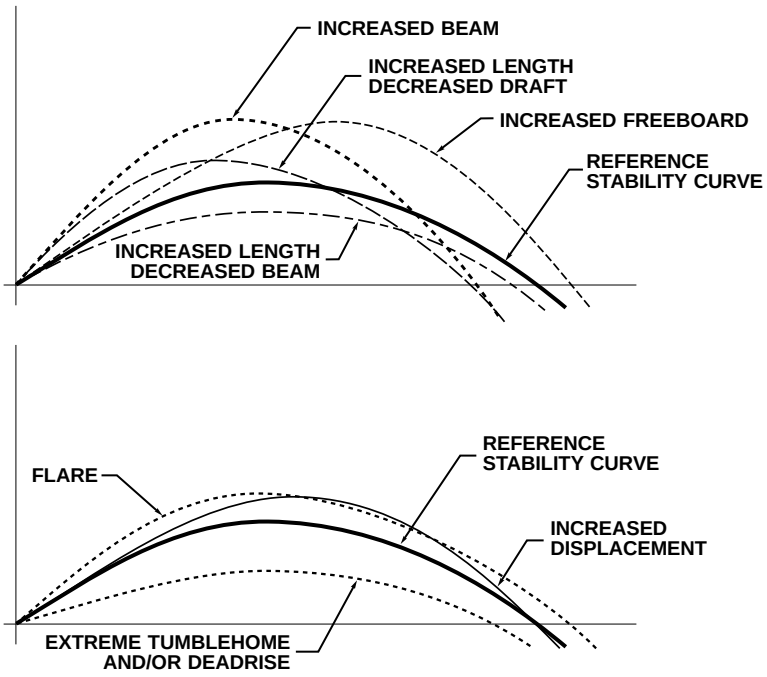
1-5.10.2 Length. If length is increased proportionally to displacement, with beam and draft held constant, *KB* and *BM* are unchanged. In practice, increasing length usually causes an increase in *KG*, reducing initial stability. If length is increased at the expense of beam, righting arms are reduced over the full range of stability. If length is increased at the expense of draft, righting arms will be increased at small angles, but decreased at large angles.

1-5.10.3 Freeboard. Increasing freeboard increases the angle of deck edge immersion, increasing righting arms at larger angles and extending the range of stability. If draft is held constant, increasing freeboard causes a rise in the center of gravity, mitigating the benefits of increased freeboard to some extent.

1-5.10.4 Draft. Reduced draft proportional to reduced displacement increases initial righting arms and the angle of deck edge immersion but decreases righting arms at large angles.

1-5.10.5 Displacement. If length, beam, and draft are held constant, displacement can be increased only by making the ship fuller. The filling out of the waterline will usually compensate for the increased volume of displacement, and *BM*, as a function of I/∇, will increase. Height of the center of gravity will also be decreased by filling out the ship's form below the waterline. These changes will enhance stability at all angles.

1-5.10.6 Side and Bottom Profile. As can be seen in Figures 1-13 and 1-25, the increase in waterplane breadth and area caused by inclining a wall-sided ship can be calculated by simple geometry. The stability curve develops good early righting arms and range of stability. Extreme deadrise (fining the bilges) or tumblehome in the vicinity of the inclined waterline reduces the increase in waterplane area and outward shift of the center of buoyancy, resulting in a shallow stability curve. Ships with flaring sides develop large righting arms because of the rapid increase in waterplane area and large shift of the center of buoyancy as the ship is inclined. A round-bottomed ship with vertical sides beginning somewhat above the water line, such as a tug or icebreaker, will roll easily to small angles of inclination but develop strong righting moments at large angles. In the same way, flare or watertight sponsons some distance above the water line will have no effect on initial stability, but will cause a sharp upward turn in the stability curve at larger angles of heel.



FROM *STABILITY AND TRIM OF FISHING VESSELS*, J. ANTHONY HIND, 1982.

Figure 1-24. Influence of Hull Form on Stability.

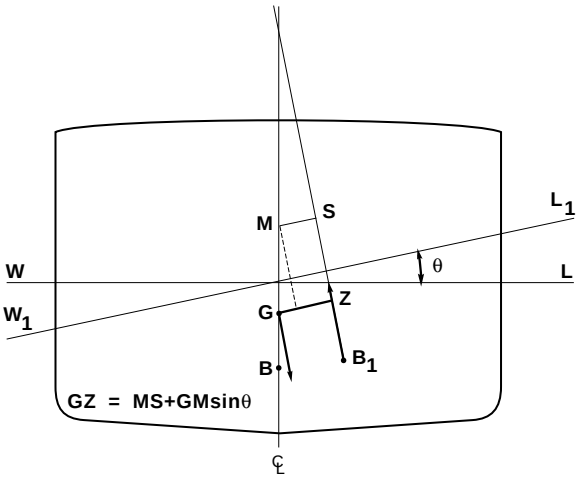


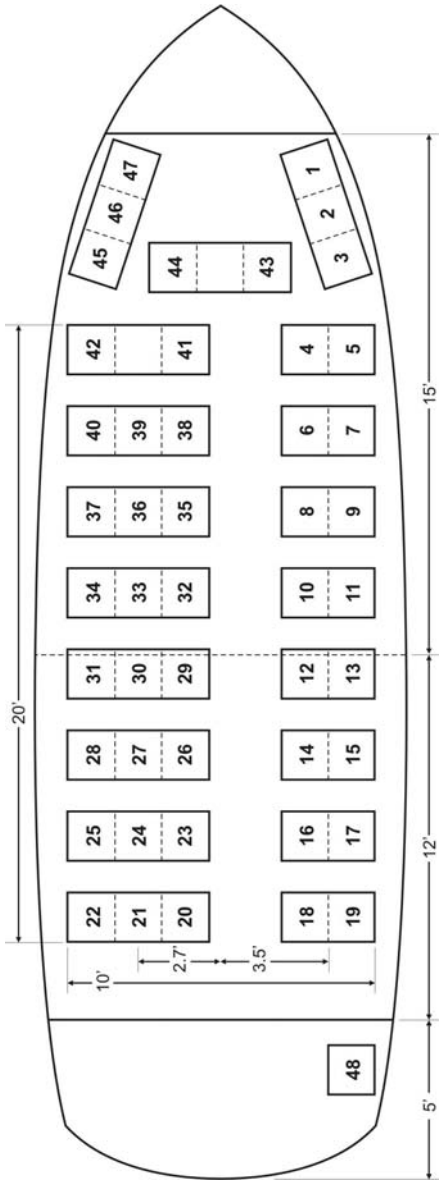
Figure 1-25. Residuary Righting Arm.

APPENDIX B

PASSENGER WEIGHT AND CENTERS

ETHAN ALLEN PASSENGER LOADING:

Seat	Weight	LCG	TCG
	lbs	ft from AP	ft from CL (port negative)
1	189	29.46	1.25
2	110	28.46	2.00
3	144	27.46	2.75
4	140	24.13	2.75
5	185	24.13	4.25
6	194	21.63	2.75
7	180	21.63	4.25
8	211	19.13	2.75
9	128	19.13	4.25
10	135	16.63	2.75
11	140	16.63	4.25
12	205	14.13	2.75
13	200	14.13	4.25
14	164	11.63	2.75
15	150	11.63	4.25
16	170	9.13	2.75
17	194	9.13	4.25
18	260	6.63	2.75
19	165	6.63	4.25
20	137	6.63	-1.20
21	198	6.63	-2.70
22	195	6.63	-4.20
23	158	9.13	-1.20
24	204	9.13	-2.70
25	170	9.13	-4.20
26	190	11.63	-1.20
27	129	11.63	-2.70
28	146	11.63	-4.20
29	135	14.13	-1.20
30	176	14.13	-2.70
31	204	14.13	-4.20
32	170	16.63	-1.20
33	142	16.63	-2.70
34	210	16.63	-4.20
35	180	19.13	-1.20
36	155	19.13	-2.70
37	217	19.13	-4.20
38	198	21.63	-1.20
39	126	21.63	-2.70
40	247	21.63	-4.20
41	173	24.13	-1.63
42	155	24.13	-3.88
43	165	26.67	1.13
44	175	26.67	-1.13
45	235	27.46	-1.25
46	230	28.46	-2.00
47	268	29.46	-3.75
48 (CREW)	170	1.38	3.50



- Total weight of passengers and crew: 8,522 lbs at 17.12 ft forward of AP and 0.2 feet to port of CL.
- Average weight of passengers (crew excluded): 8,352 lbs / 47 = 177.7 lbs.

APPENDIX C

ENGINE COMPARTMENT FLOODING DETAIL RESULTS

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Intact Trim and Stability Summary
100

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.34F	0.01P	88.2	
Misc. Tanks	834.5	0.97	5.81A	0.11P	2,730.0	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	24,572.0	5.74	1.66A	0.07P	2,818.2	
Stability Calculation			**Trim Calculation**			
KMt	7.74	ft	LCF Draft		3.01	ft
VCG	5.74	ft	LCB		1.59A	ft-MS
GMt (Solid)	2.00	ft	LCF		3.27A	ft-MS
FSc	0.11	ft	MT1in		1.61	ft-LT/in
GMt (Corrected)	1.88	ft	Trim		0.65	ft-F
			List		2.1P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.75	ft				
Draft at M.S.	3.08	ft				
Draft at F.P.	3.40	ft				
Draft at Aft Marks	2.74	ft				
Draft at Mid Marks	3.08	ft				
Draft at Fwd Marks	3.42	ft				

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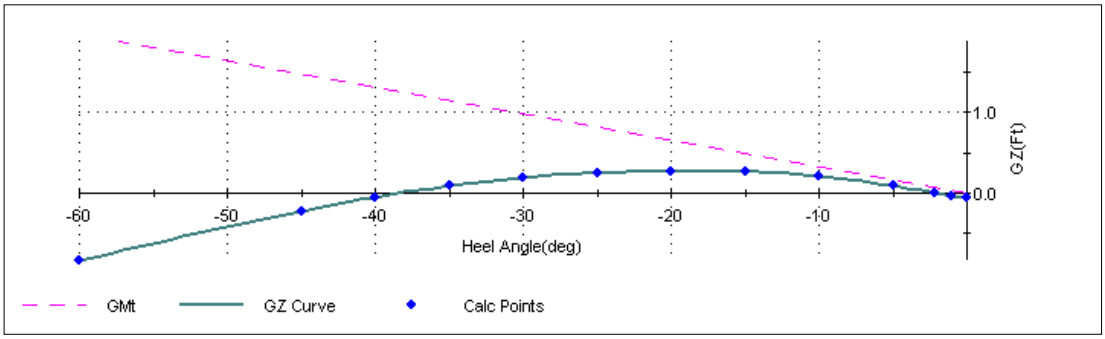
Righting Arm Summary
100

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.1P
Angle at Maximum GZ	**deg**	17.9P
Area to 17.9 deg	**ft-deg**	2.89
Maximum GZ	**ft**	0.27
Range of Positive GZ	**deg**	36.1

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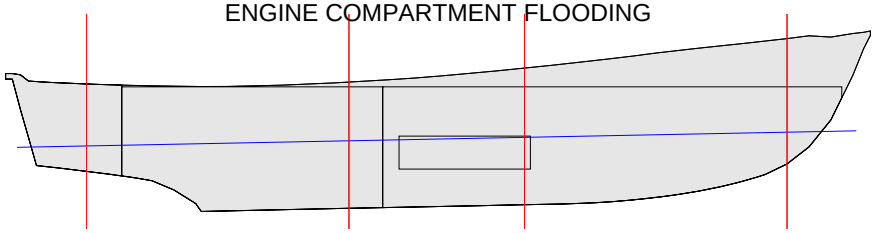
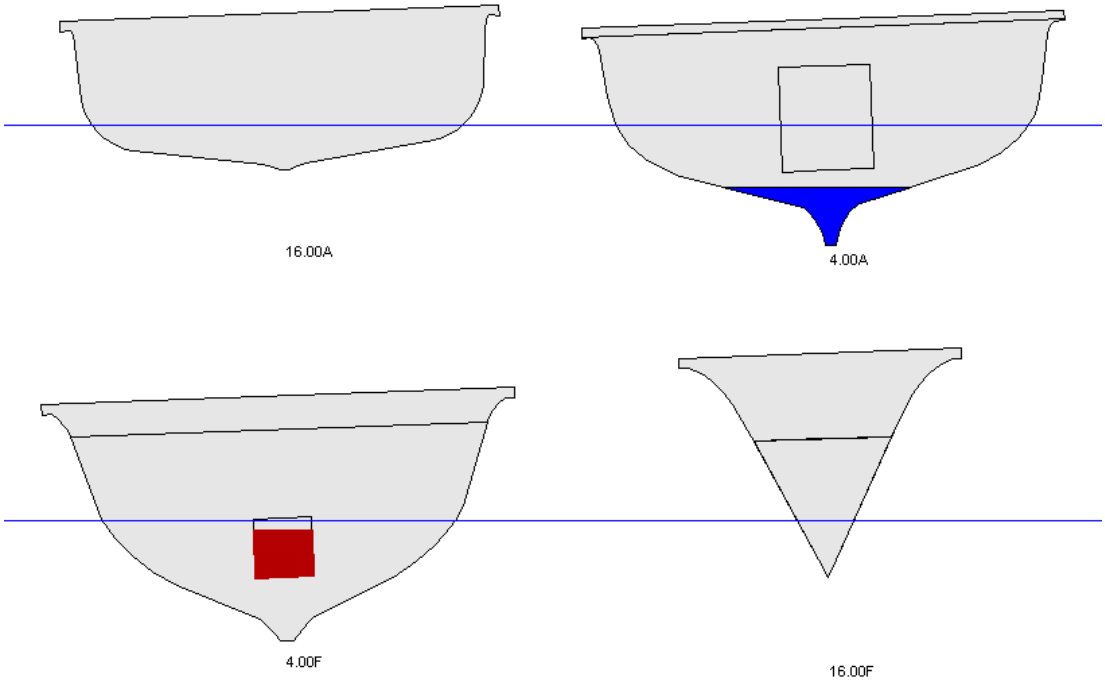
Cross Sections
100

ENGINE COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
200

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.33F	0.01P	88.2	
Misc. Tanks	1,669.1	1.26	6.15A	0.24P	10,322.5	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	25,406.6	5.61	1.82A	0.08P	10,410.7	
Stability Calculation			**Trim Calculation**			
KMt	7.69	ft	LCF Draft		3.06	ft
VCG	5.61	ft	LCB		1.76A	ft-MS
GMt (Solid)	2.08	ft	LCF		3.29A	ft-MS
FSc	0.41	ft	MT1in		1.62	ft-LT/in
GMt (Corrected)	1.67	ft	Trim		0.59	ft-F
			List		2.3P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.82	ft				
Draft at M.S.	3.11	ft				
Draft at F.P.	3.41	ft				
Draft at Aft Marks	2.81	ft				
Draft at Mid Marks	3.11	ft				
Draft at Fwd Marks	3.42	ft				

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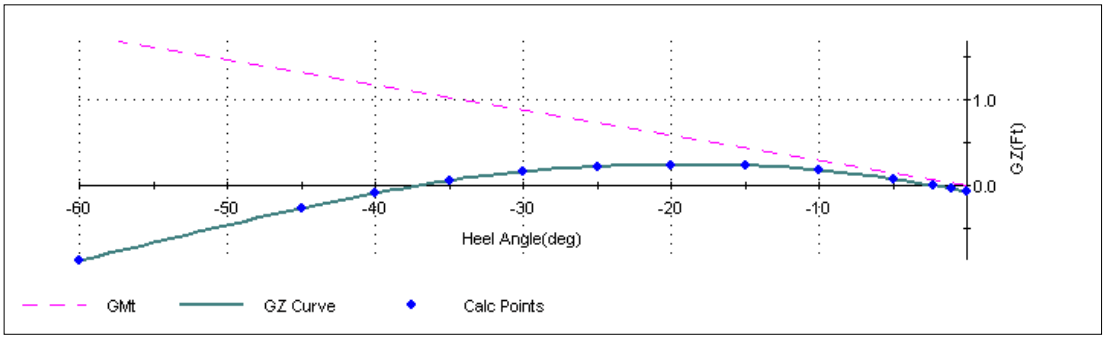
Righting Arm Summary
200

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.3P
Angle at Maximum GZ	**deg**	18.4P
Area to 18.4 deg	**ft-deg**	2.72
Maximum GZ	**ft**	0.24
Range of Positive GZ	**deg**	34.6

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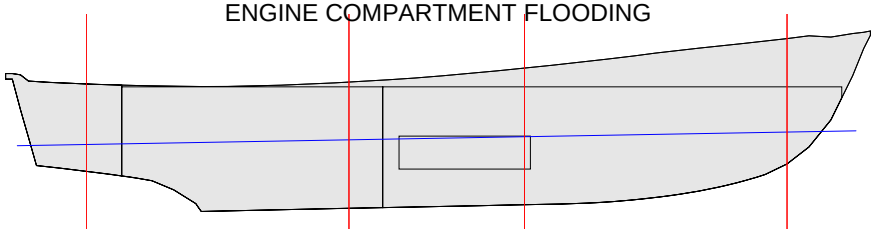
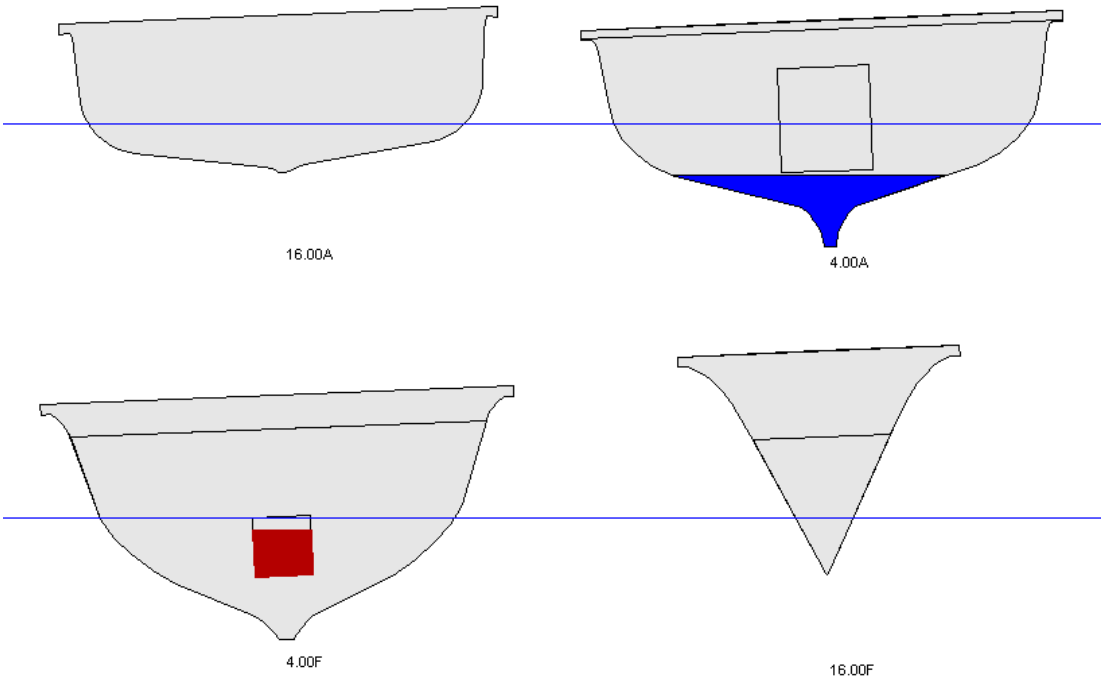
Cross Sections
200

ENGINE COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
400

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.32F	0.01P	88.1	
Misc. Tanks	3,338.2	1.58	7.04A	0.57P	30,154.5	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	27,075.7	5.38	2.20A	0.13P	30,242.6	
Stability Calculation			**Trim Calculation**			
KMt	7.56	ft	LCF Draft		3.14	ft
VCG	5.38	ft	LCB		2.16A	ft-MS
GMt (Solid)	2.19	ft	LCF		3.35A	ft-MS
FSc	1.12	ft	MT1in		1.64	ft-LT/in
GMt (Corrected)	1.07	ft	Trim		0.41	ft-F
			List		3.5P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.98	ft				
Draft at M.S.	3.18	ft				
Draft at F.P.	3.39	ft				
Draft at Aft Marks	2.97	ft				
Draft at Mid Marks	3.18	ft				
Draft at Fwd Marks	3.39	ft				

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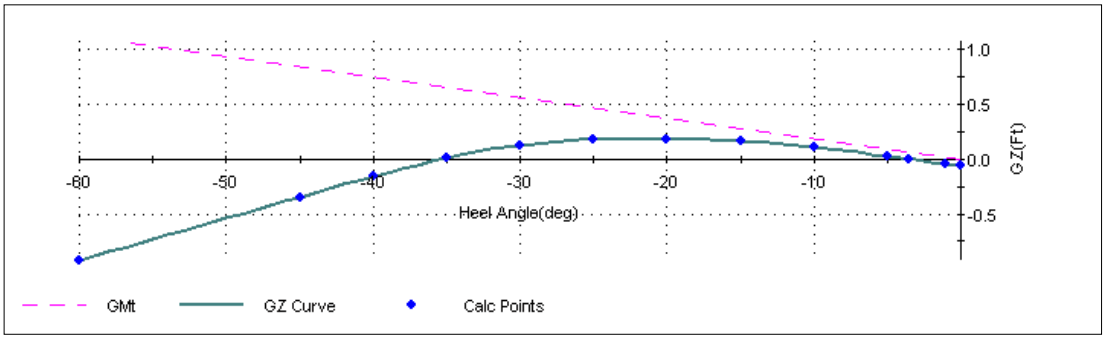
Righting Arm Summary
400

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	3.5P
Angle at Maximum GZ	**deg**	22.8P
Area to 22.8 deg	**ft-deg**	2.45
Maximum GZ	**ft**	0.18
Range of Positive GZ	**deg**	31.8

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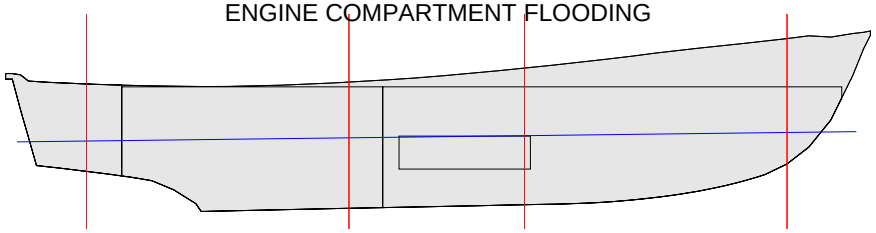
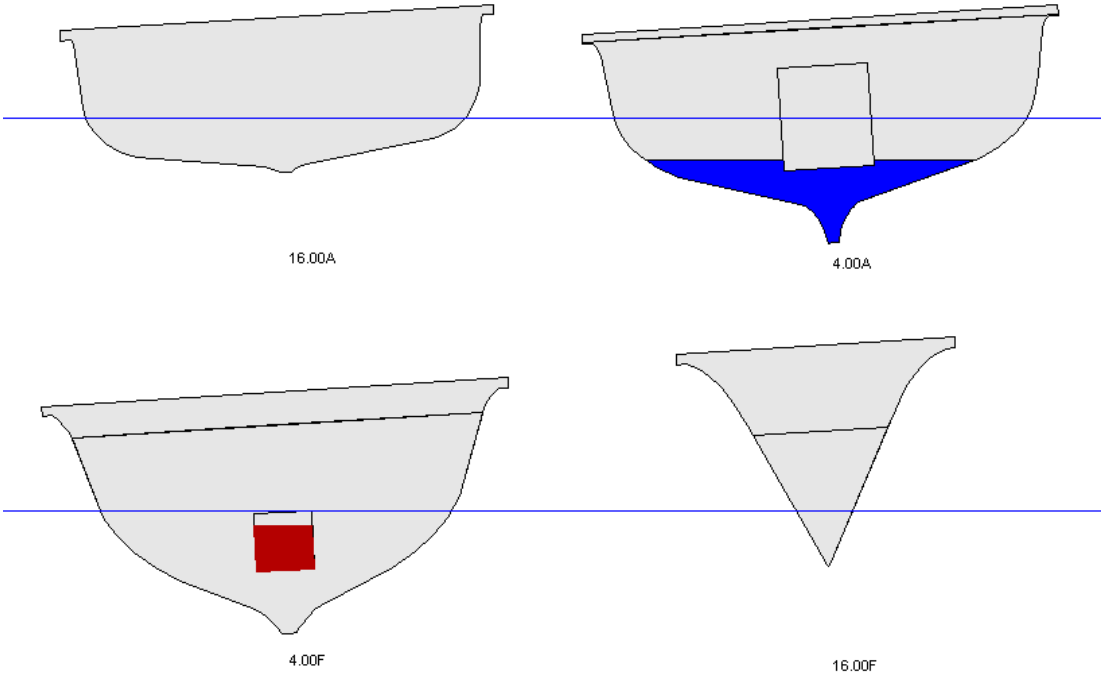
Cross Sections
400

ENGINE COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
600

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.30F	0.02P	88.1	
Misc. Tanks	5,007.2	1.81	7.61A	0.97P	47,497.6	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	28,744.7	5.20	2.58A	0.23P	47,585.7	
Stability Calculation			**Trim Calculation**			
KMt	7.44	ft	LCF Draft		3.22	ft
VCG	5.20	ft	LCB		2.56A	ft-MS
GMt (Solid)	2.25	ft	LCF		3.39A	ft-MS
FSc	1.66	ft	MT1in		1.65	ft-LT/in
GMt (Corrected)	0.60	ft	Trim		0.20	ft-F
			List		6.0P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	3.15	ft				
Draft at M.S.	3.24	ft				
Draft at F.P.	3.34	ft				
Draft at Aft Marks	3.14	ft				
Draft at Mid Marks	3.24	ft				
Draft at Fwd Marks	3.34	ft				

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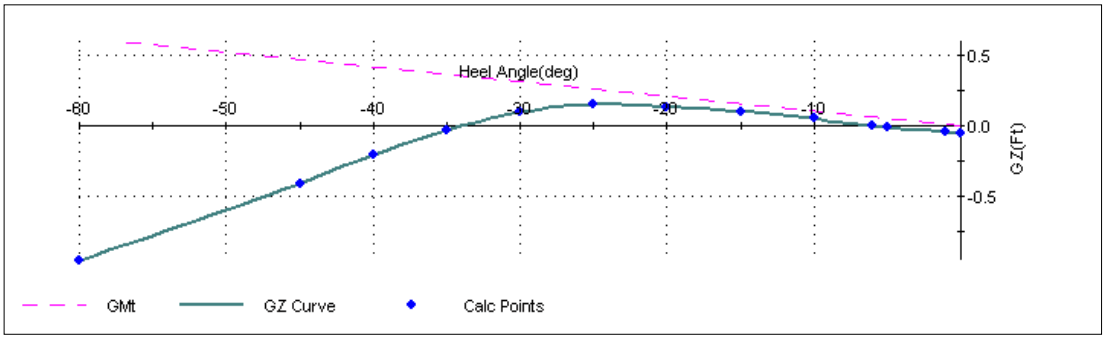
Righting Arm Summary
600

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	6.0P
Angle at Maximum GZ	**deg**	24.2P
Area to 24.2 deg	**ft-deg**	1.75
Maximum GZ	**ft**	0.15
Range of Positive GZ	**deg**	27.9

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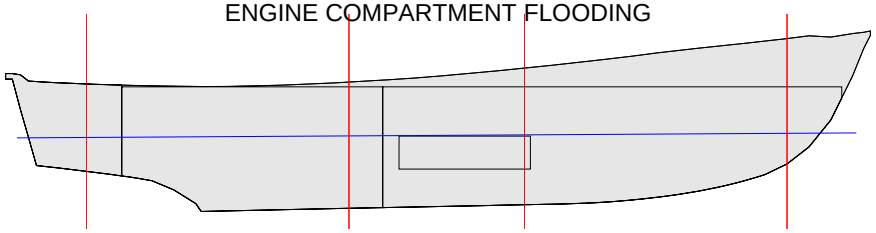
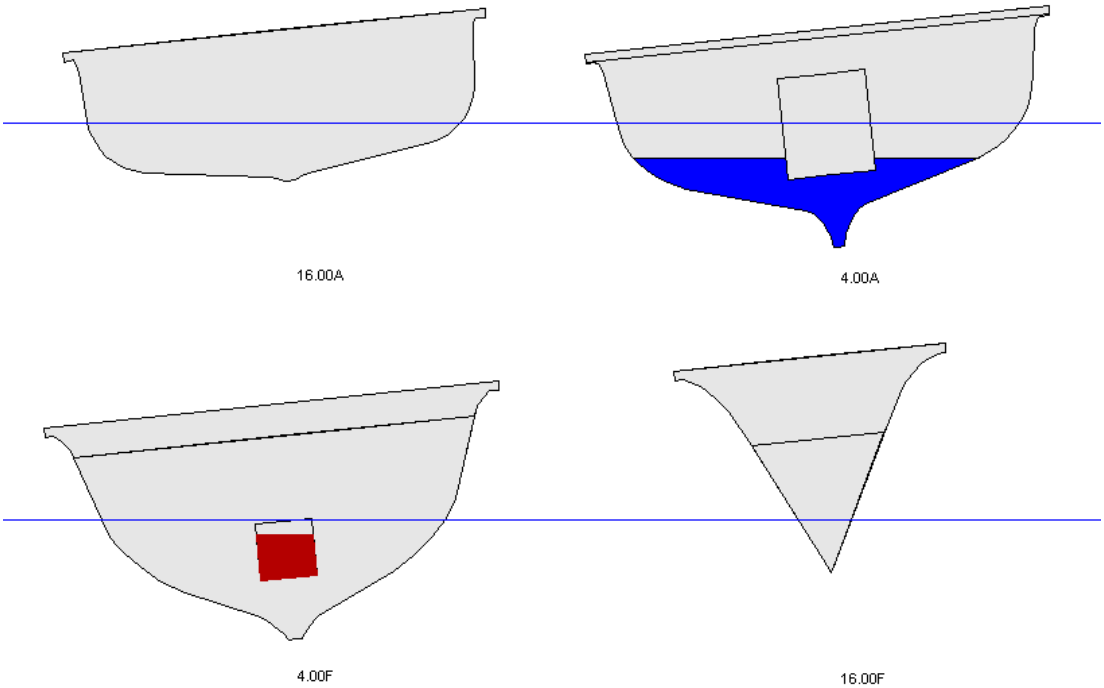
Cross Sections
600

ENGINE COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
800

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.28F	0.03P	87.1	
Misc. Tanks	6,676.3	2.03	7.92A	1.37P	59,434.2	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	30,413.8	5.06	2.92A	0.36P	59,521.3	
Stability Calculation			**Trim Calculation**			
KMt	7.31	ft	LCF Draft		3.30	ft
VCG	5.06	ft	LCB		2.92A	ft-MS
GMt (Solid)	2.27	ft	LCF		3.42A	ft-MS
FSc	1.96	ft	MT1in		1.66	ft-LT/in
GMt (Corrected)	0.34	ft	Trim		0.02	ft-A
			List		9.5P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	3.30	ft				
Draft at M.S.	3.29	ft				
Draft at F.P.	3.28	ft				
Draft at Aft Marks	3.30	ft				
Draft at Mid Marks	3.29	ft				
Draft at Fwd Marks	3.28	ft				

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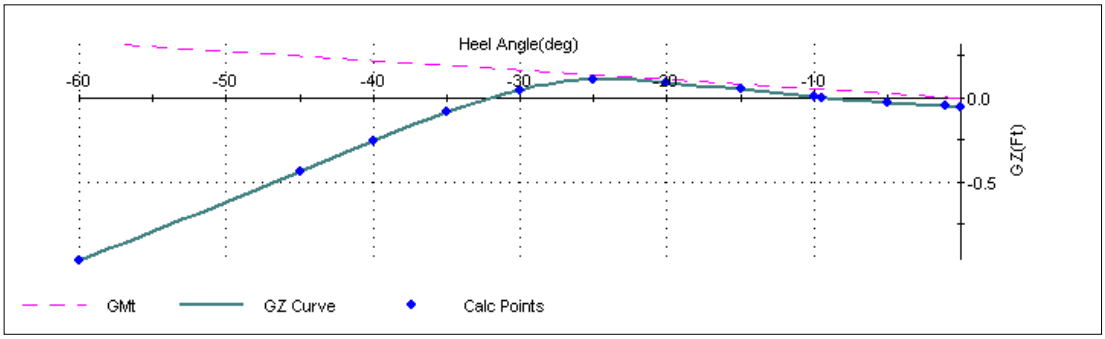
Righting Arm Summary
800

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	9.5P
Angle at Maximum GZ	**deg**	24.3P
Area to 24.3 deg	**ft-deg**	1.00
Maximum GZ	**ft**	0.11
Range of Positive GZ	**deg**	22.6

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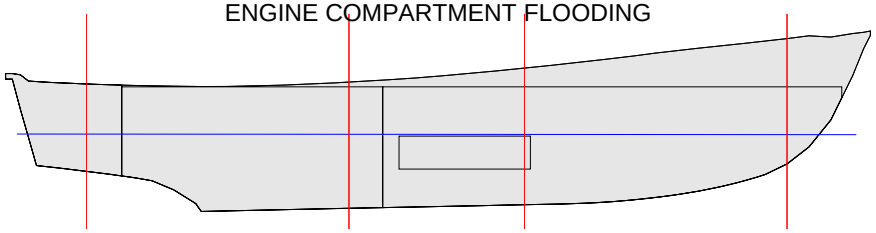
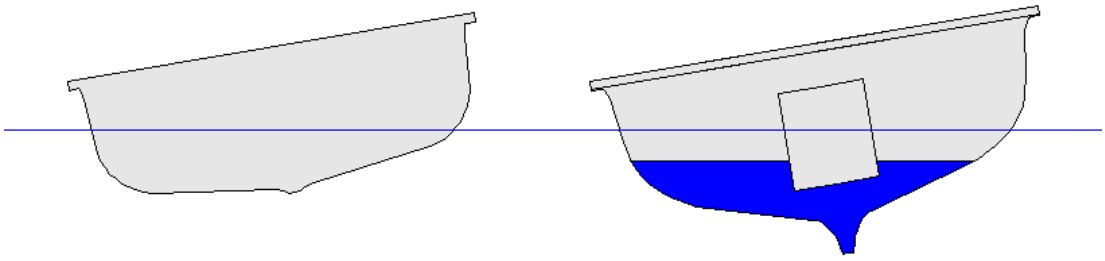
Cross Sections
800

ENGINE COMPARTMENT FLOODING

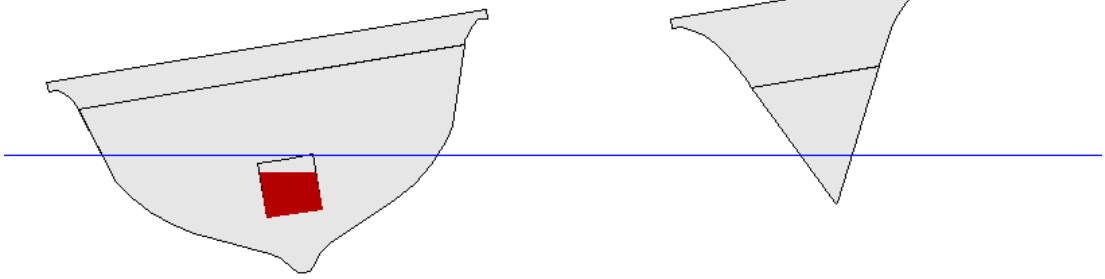


Sections looking forward - units (ft-MS)



16.00A

4.00A



4.00F

16.00F

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Intact Trim and Stability Summary
1000

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.27F	0.04P	88.1	
Misc. Tanks	8,345.4	2.25	8.11A	1.68P	67,645.2	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	32,082.9	4.96	3.23A	0.49P	67,733.3	
Stability Calculation			**Trim Calculation**			
KMt	7.19	ft	LCF Draft		3.36	ft
VCG	4.96	ft	LCB		3.26A	ft-MS
GMt (Solid)	2.27	ft	LCF		3.45A	ft-MS
FSc	2.11	ft	MT1in		1.67	ft-LT/in
GMt (Corrected)	0.21	ft	Trim		0.25	ft-A
			List		13.2P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	3.46	ft				
Draft at M.S.	3.33	ft				
Draft at F.P.	3.21	ft				
Draft at Aft Marks	3.46	ft				
Draft at Mid Marks	3.33	ft				
Draft at Fwd Marks	3.20	ft				

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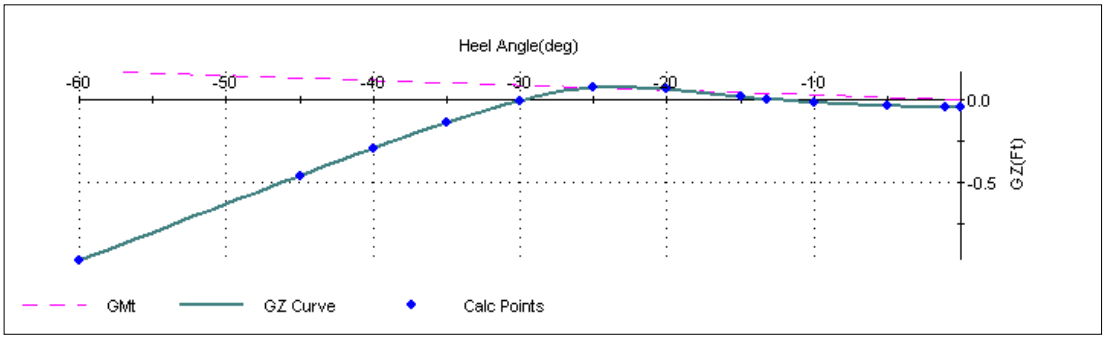
Righting Arm Summary
1000

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	13.2P
Angle at Maximum GZ	**deg**	23.4P
Area to 23.4 deg	**ft-deg**	0.46
Maximum GZ	**ft**	0.07
Range of Positive GZ	**deg**	16.3

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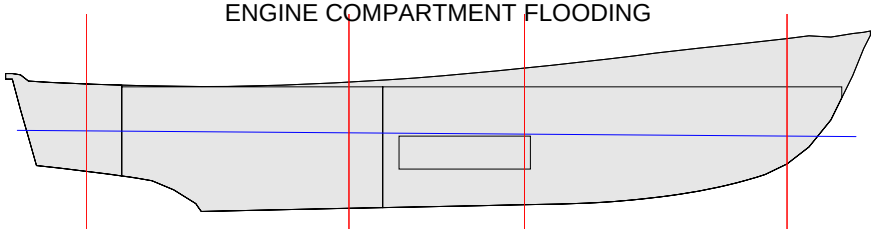
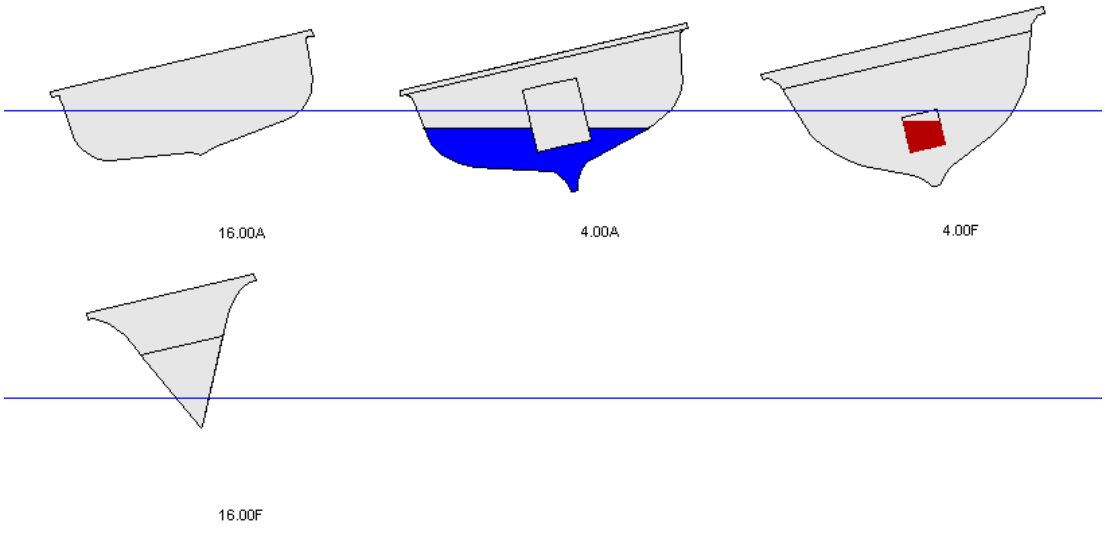
Cross Sections
1000

ENGINE COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
1200

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.25F	0.05P	88.1	
Misc. Tanks	10,014.5	2.46	8.24A	1.86P	73,496.2	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	33,752.0	4.89	3.51A	0.60P	73,584.4	
Stability Calculation			**Trim Calculation**			
KMt	7.06	ft	LCF Draft		3.42	ft
VCG	4.89	ft	LCB		3.55A	ft-MS
GMt (Solid)	2.25	ft	LCF		3.49A	ft-MS
FSc	2.18	ft	MT1in		1.68	ft-LT/in
GMt (Corrected)	0.14	ft	Trim		0.47	ft-A
			List		16.4P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	3.61	ft				
Draft at M.S.	3.37	ft				
Draft at F.P.	3.13	ft				
Draft at Aft Marks	3.61	ft				
Draft at Mid Marks	3.37	ft				
Draft at Fwd Marks	3.12	ft				

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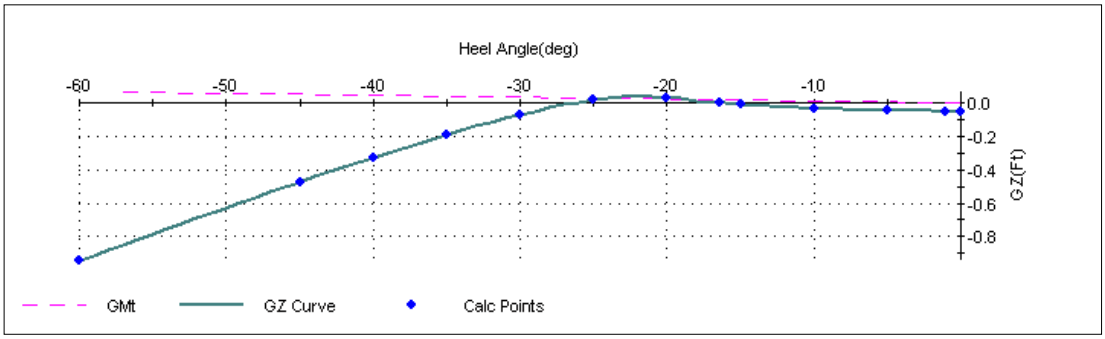
Righting Arm Summary
1200

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	16.4P
Angle at Maximum GZ	**deg**	21.7P
Area to 21.7 deg	**ft-deg**	0.13
Maximum GZ	**ft**	0.04
Range of Positive GZ	**deg**	9.9

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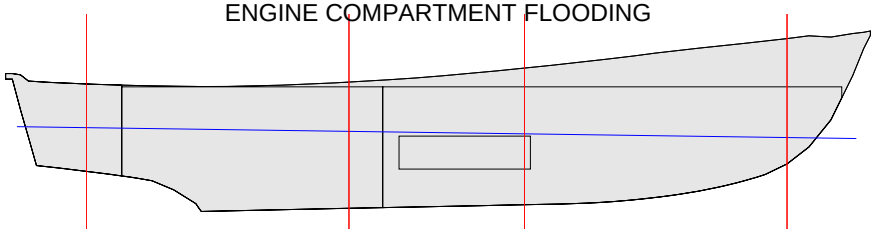
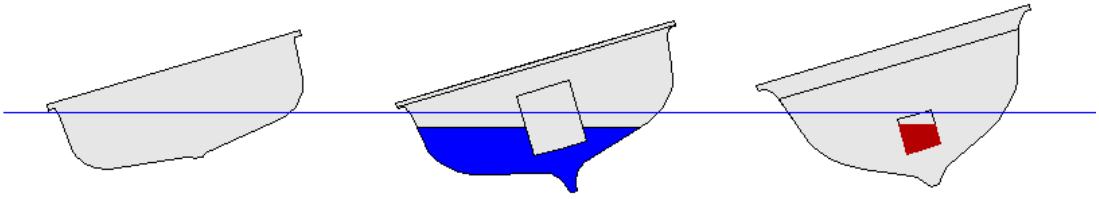
Cross Sections
1200

ENGINE COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
1450

ENGINE COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.23F	0.05P	88.2	
Misc. Tanks	12,100.8	2.65	8.35A	1.85P	78,386.8	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	35,838.3	4.81	3.82A	0.67P	78,474.9	
Stability Calculation			**Trim Calculation**			
KMt	6.91	ft	LCF Draft		3.51	ft
VCG	4.81	ft	LCB		3.87A	ft-MS
GMt (Solid)	2.20	ft	LCF		3.57A	ft-MS
FSc	2.19	ft	MT1in		1.71	ft-LT/in
GMt (Corrected)	0.10	ft	Trim		0.73	ft-A
			List		18.1P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	3.80	ft				
Draft at M.S.	3.43	ft				
Draft at F.P.	3.07	ft				
Draft at Aft Marks	3.81	ft				
Draft at Mid Marks	3.43	ft				
Draft at Fwd Marks	3.06	ft				

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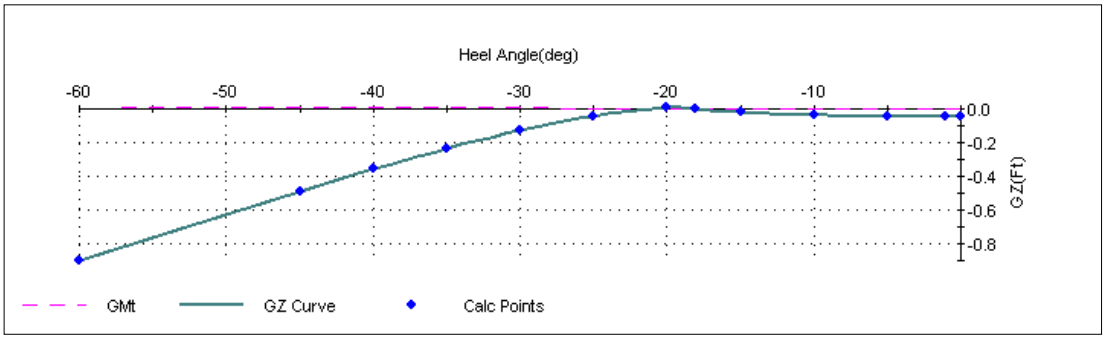
4/20/2006

Righting Arm Summary
1450

ENGINE COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	18.1P
Angle at Maximum GZ	**deg**	19.7P
Area to 19.7 deg	**ft-deg**	0.01
Maximum GZ	**ft**	0.00
Range of Positive GZ	**deg**	3.0

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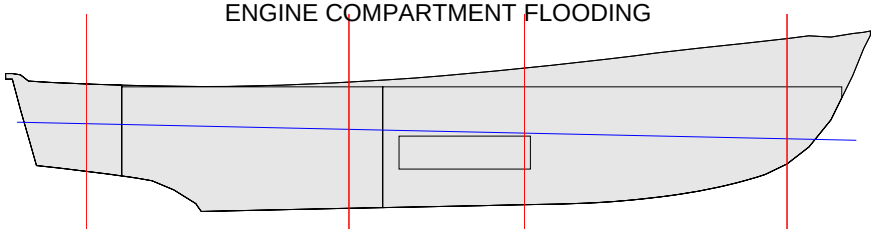
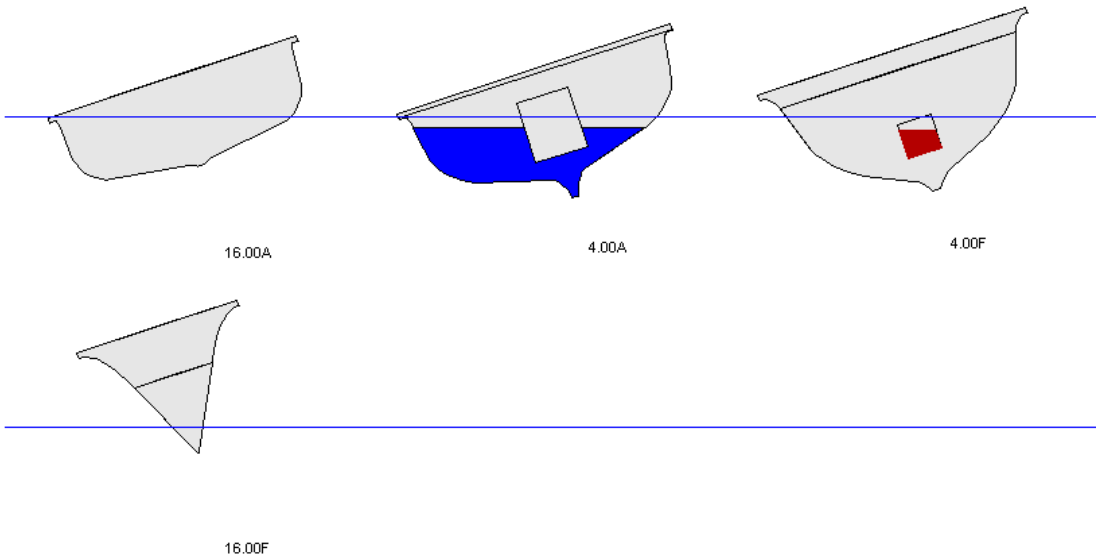
Cross Sections
1450

ENGINE COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



APPENDIX D

FORWARD COMPARTMENT FLOODING DETAIL RESULTS

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4/5/2006

Intact Trim and Stability Summary
100 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.35F	0.01P	88.1	
Misc. Tanks	834.2	0.71	4.66F	0.04P	1,003.3	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	24,571.7	5.74	1.31A	0.07P	1,091.4	
Stability Calculation			**Trim Calculation**			
KMt	7.72	ft	LCF Draft		3.01	ft
VCG	5.74	ft	LCB		1.21A	ft-MS
GMt (Solid)	1.99	ft	LCF		3.15A	ft-MS
FSc	0.04	ft	MT1in		1.62	ft-LT/in
GMt (Corrected)	1.94	ft	Trim		0.87	ft-F
			List		2.1P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.66	ft				
Draft at M.S.	3.10	ft				
Draft at F.P.	3.53	ft				
Draft at Aft Marks	2.65	ft				
Draft at Mid Marks	3.10	ft				
Draft at Fwd Marks	3.55	ft				

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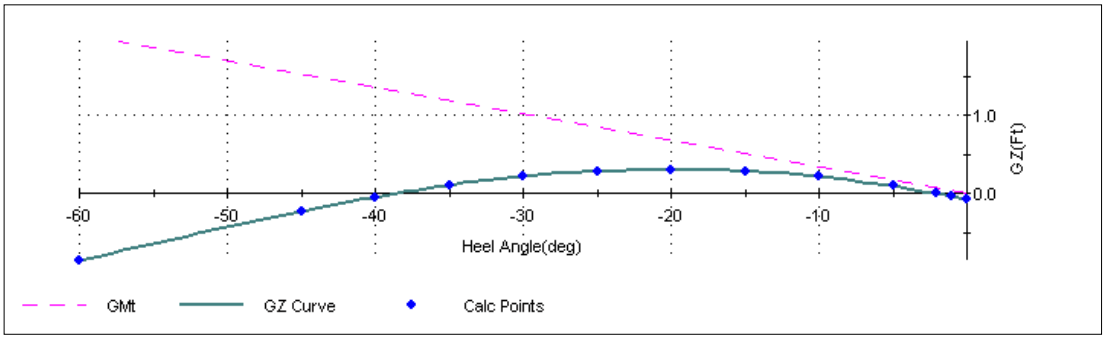
4/5/2006

Righting Arm Summary
100 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.1P
Angle at Maximum GZ	**deg**	19.4P
Area to 19.4 deg	**ft-deg**	3.70
Maximum GZ	**ft**	0.30
Range of Positive GZ	**deg**	36.5

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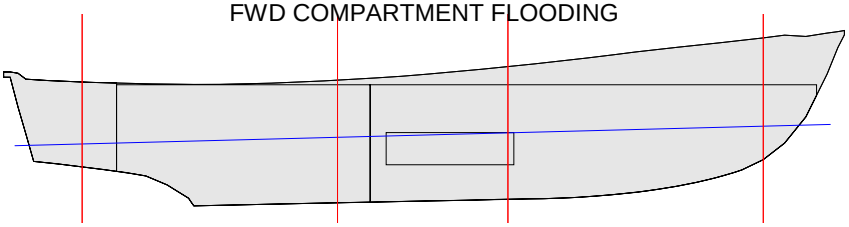
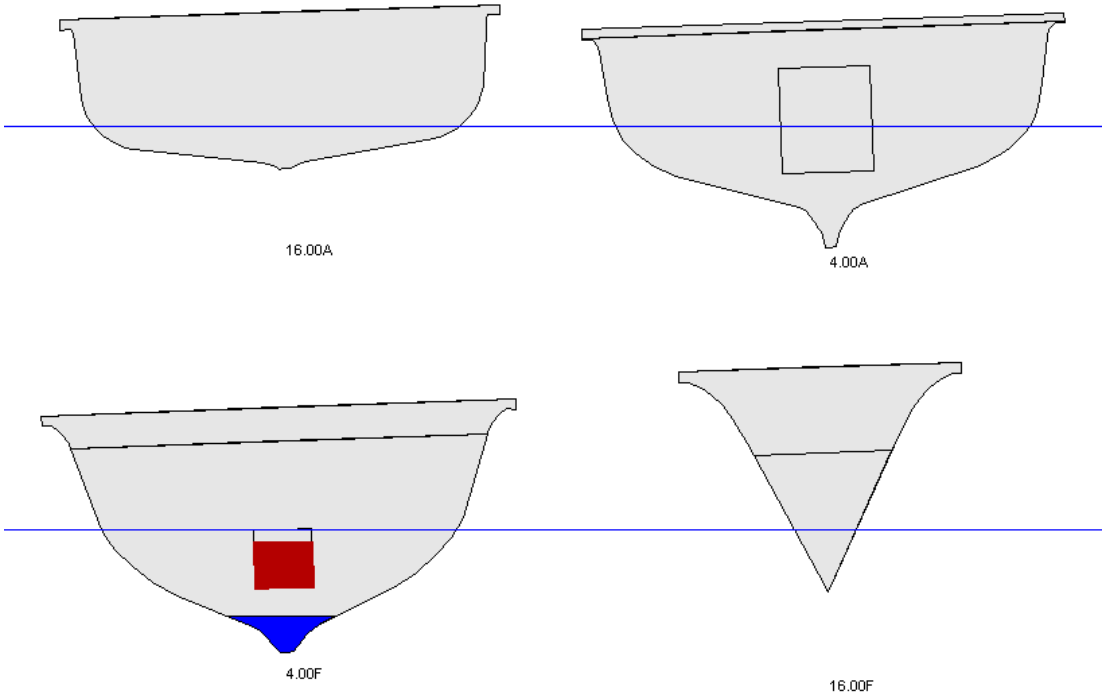
4/5/2006

Cross Sections
100 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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HECSALV 7.6.6beta
4/5/2006

Intact Trim and Stability Summary
200 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.37F	0.01P	88.1	
Misc. Tanks	1,668.3	0.95	4.83F	0.08P	3,793.6	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	25,405.8	5.59	1.10A	0.07P	3,881.7	
Stability Calculation			**Trim Calculation**			
KMt	7.65	ft	LCF Draft		3.06	ft
VCG	5.59	ft	LCB		1.00A	ft-MS
GMt (Solid)	2.06	ft	LCF		3.05A	ft-MS
FSc	0.15	ft	MT1in		1.65	ft-LT/in
GMt (Corrected)	1.91	ft	Trim		1.03	ft-F
			List		2.0P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.64	ft				
Draft at M.S.	3.16	ft				
Draft at F.P.	3.67	ft				
Draft at Aft Marks	2.62	ft				
Draft at Mid Marks	3.16	ft				
Draft at Fwd Marks	3.69	ft				

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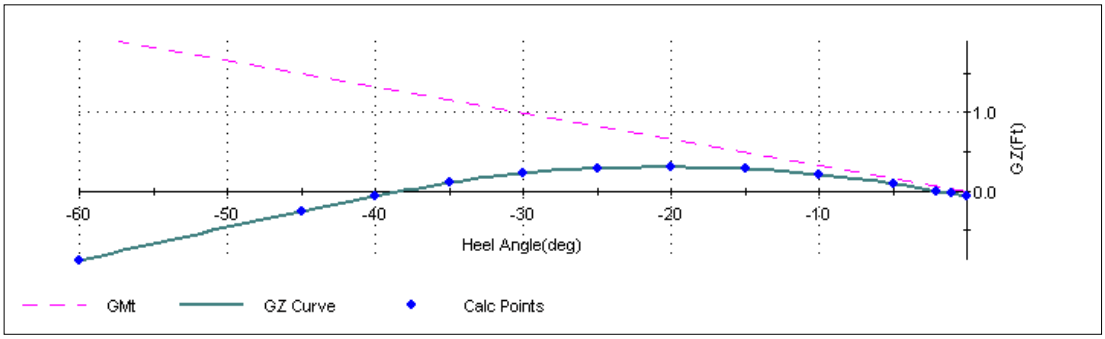
4/5/2006

Righting Arm Summary
200 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.0P
Angle at Maximum GZ	**deg**	20.3P
Area to 20.3 deg	**ft-deg**	3.94
Maximum GZ	**ft**	0.30
Range of Positive GZ	**deg**	36.0

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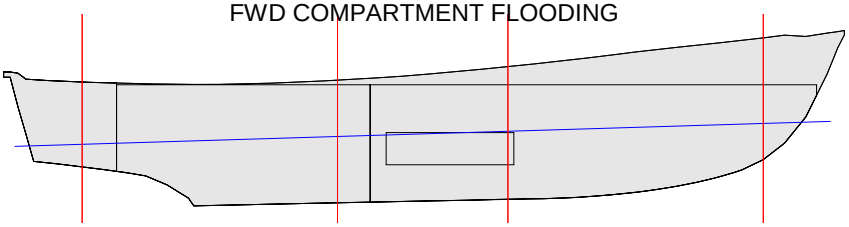
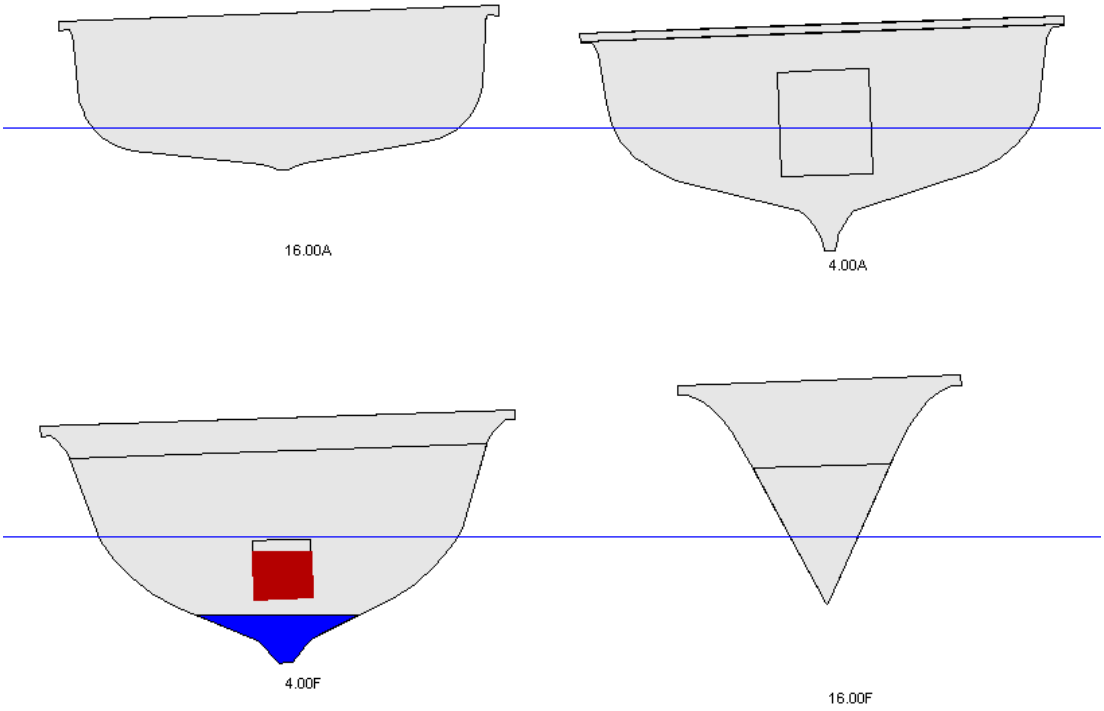
4/5/2006

Cross Sections
200 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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4/5/2006

Intact Trim and Stability Summary
400 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.39F	0.01P	88.1	
Misc. Tanks	3,336.7	1.25	4.98F	0.12P	11,435.2	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	27,074.2	5.34	0.72A	0.08P	11,523.3	
Stability Calculation			**Trim Calculation**			
KMt	7.51	ft	LCF Draft		3.16	ft
VCG	5.34	ft	LCB		0.59A	ft-MS
GMt (Solid)	2.17	ft	LCF		2.86A	ft-MS
FSc	0.43	ft	MT1in		1.69	ft-LT/in
GMt (Corrected)	1.75	ft	Trim		1.34	ft-F
			List		2.1P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.60	ft				
Draft at M.S.	3.27	ft				
Draft at F.P.	3.94	ft				
Draft at Aft Marks	2.58	ft				
Draft at Mid Marks	3.27	ft				
Draft at Fwd Marks	3.97	ft				

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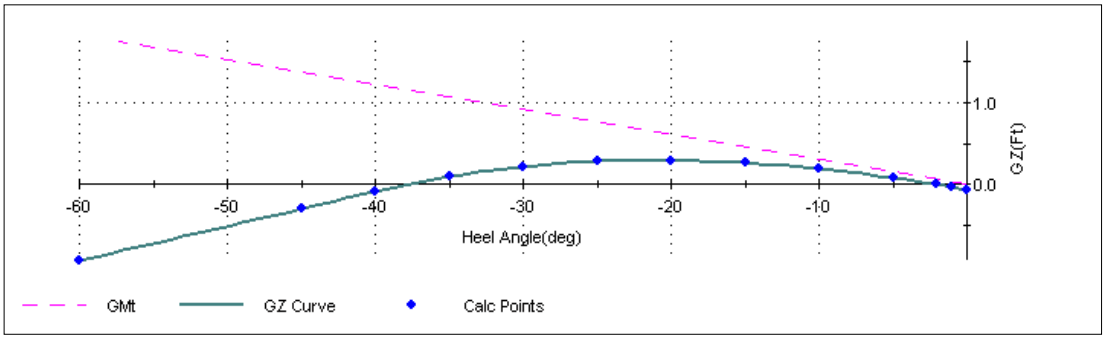
4/5/2006

Righting Arm Summary
400 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.1P
Angle at Maximum GZ	**deg**	22.3P
Area to 22.3 deg	**ft-deg**	4.23
Maximum GZ	**ft**	0.29
Range of Positive GZ	**deg**	35.7

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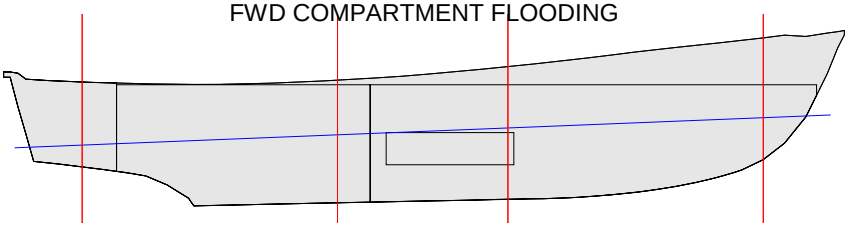
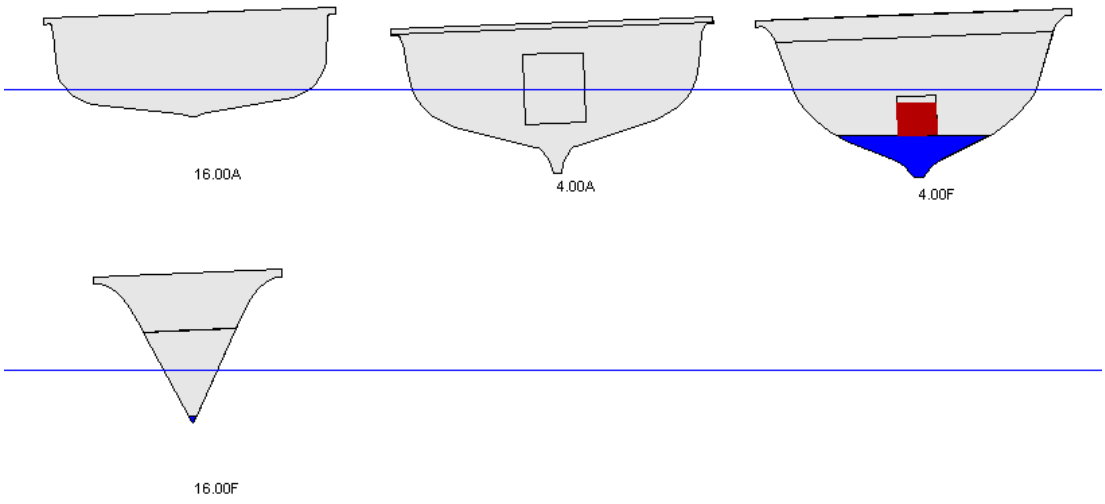
4/5/2006

Cross Sections
400 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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4/5/2006

Intact Trim and Stability Summary
600 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.42F	0.01P	88.2	
Misc. Tanks	5,005.0	1.47	5.17F	0.14P	18,972.7	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	28,742.5	5.14	0.35A	0.08P	19,060.9	
Stability Calculation			**Trim Calculation**			
KMt	7.37	ft	LCF Draft		3.25	ft
VCG	5.14	ft	LCB		0.21A	ft-MS
GMt (Solid)	2.23	ft	LCF		2.69A	ft-MS
FSc	0.66	ft	MT1in		1.74	ft-LT/in
GMt (Corrected)	1.57	ft	Trim		1.66	ft-F
			List		2.2P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.56	ft				
Draft at M.S.	3.39	ft				
Draft at F.P.	4.22	ft				
Draft at Aft Marks	2.53	ft				
Draft at Mid Marks	3.39	ft				
Draft at Fwd Marks	4.25	ft				

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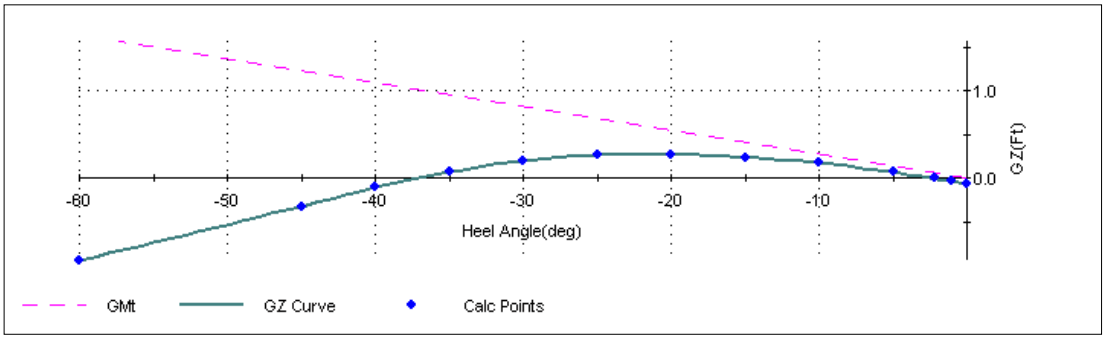
4/5/2006

Righting Arm Summary
600 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.2P
Angle at Maximum GZ	**deg**	22.5P
Area to 22.5 deg	**ft-deg**	3.89
Maximum GZ	**ft**	0.27
Range of Positive GZ	**deg**	34.9

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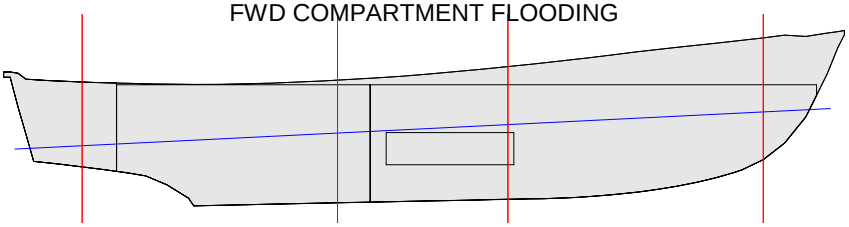
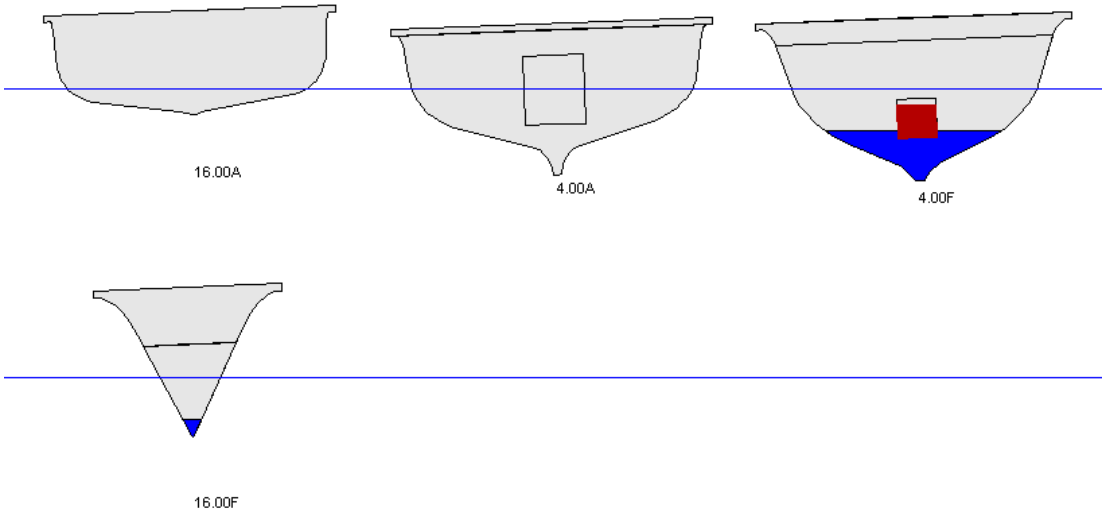
Cross Sections
600 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
800 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.44F	0.01P	88.2	
Misc. Tanks	6,673.3	1.67	5.38F	0.16P	26,158.6	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	30,410.8	4.98	0.00A	0.09P	26,246.8	
Stability Calculation			**Trim Calculation**			
KMt	7.24	ft	LCF Draft		3.35	ft
VCG	4.98	ft	LCB		0.15F	ft-MS
GMt (Solid)	2.26	ft	LCF		2.52A	ft-MS
FSc	0.86	ft	MT1in		1.78	ft-LT/in
GMt (Corrected)	1.40	ft	Trim		1.98	ft-F
			List		2.3P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.51	ft				
Draft at M.S.	3.50	ft				
Draft at F.P.	4.49	ft				
Draft at Aft Marks	2.47	ft				
Draft at Mid Marks	3.50	ft				
Draft at Fwd Marks	4.52	ft				

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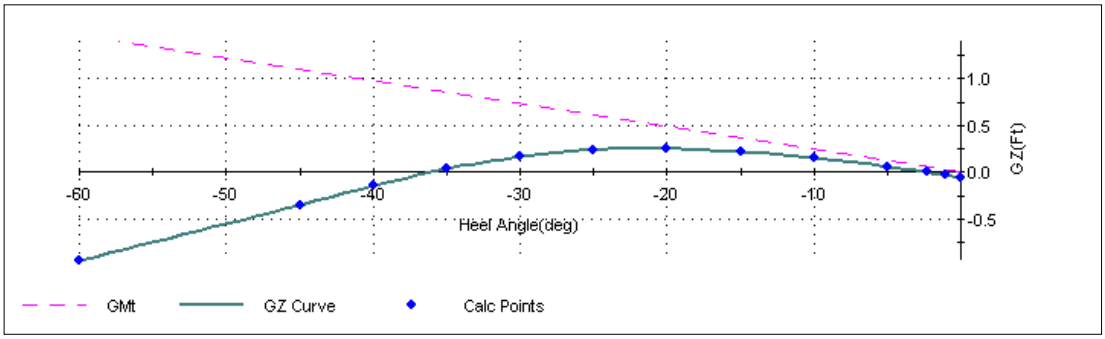
Righting Arm Summary
800 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.3P
Angle at Maximum GZ	**deg**	21.7P
Area to 21.7 deg	**ft-deg**	3.29
Maximum GZ	**ft**	0.26
Range of Positive GZ	**deg**	33.8

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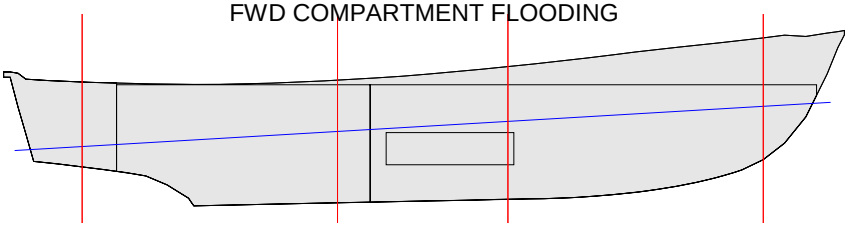
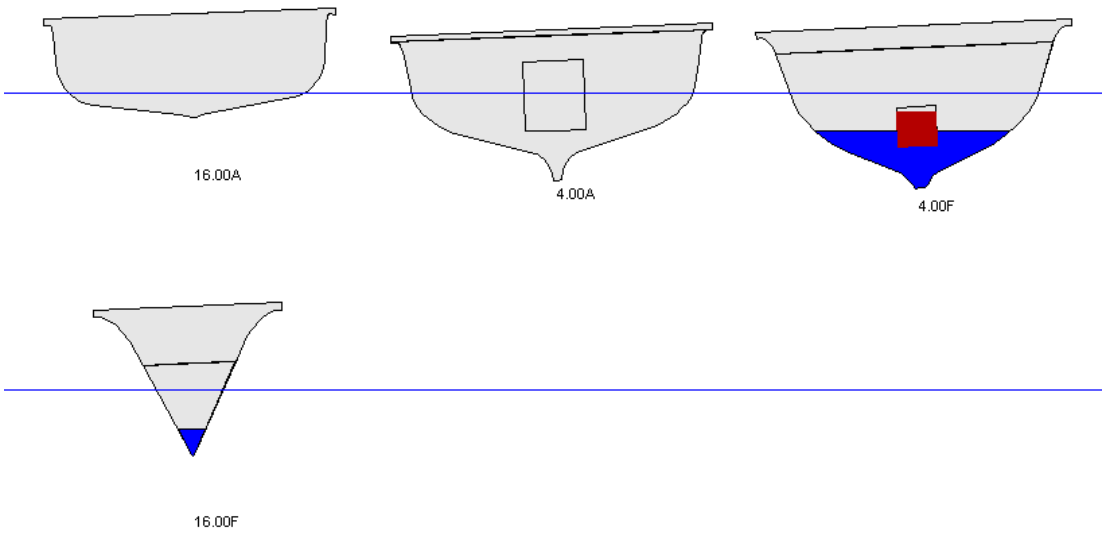
Cross Sections
800 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
1,000 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.47F	0.01P	88.2	
Misc. Tanks	8,341.7	1.84	5.56F	0.17P	32,608.5	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	32,079.2	4.85	0.33F	0.10P	32,696.7	
Stability Calculation			**Trim Calculation**			
KMt	7.14	ft	LCF Draft		3.45	ft
VCG	4.85	ft	LCB		0.48F	ft-MS
GMt (Solid)	2.28	ft	LCF		2.34A	ft-MS
FSc	1.02	ft	MT1in		1.81	ft-LT/in
GMt (Corrected)	1.26	ft	Trim		2.29	ft-F
			List		2.4P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.46	ft				
Draft at M.S.	3.61	ft				
Draft at F.P.	4.75	ft				
Draft at Aft Marks	2.42	ft				
Draft at Mid Marks	3.61	ft				
Draft at Fwd Marks	4.80	ft				

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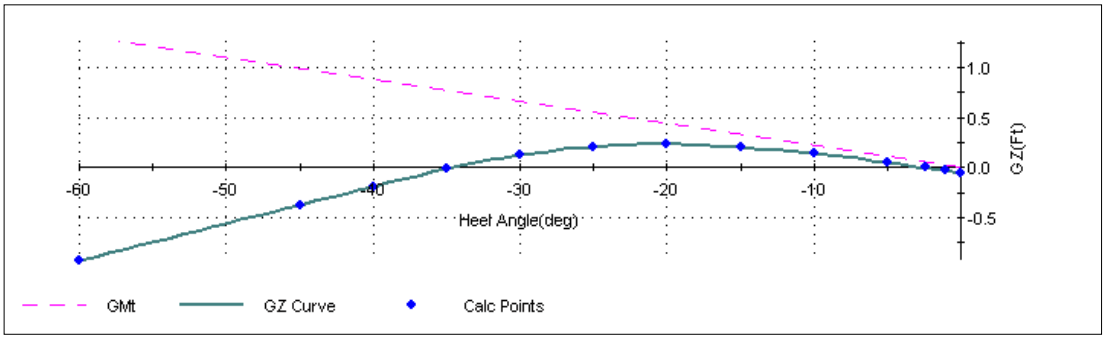
4/5/2006

Righting Arm Summary
1,000 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.4P
Angle at Maximum GZ	**deg**	20.6P
Area to 20.6 deg	**ft-deg**	2.75
Maximum GZ	**ft**	0.23
Range of Positive GZ	**deg**	32.1

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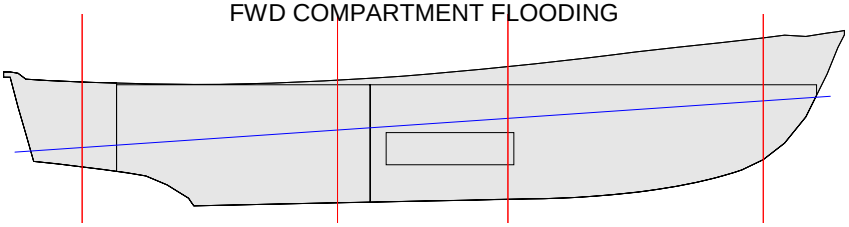
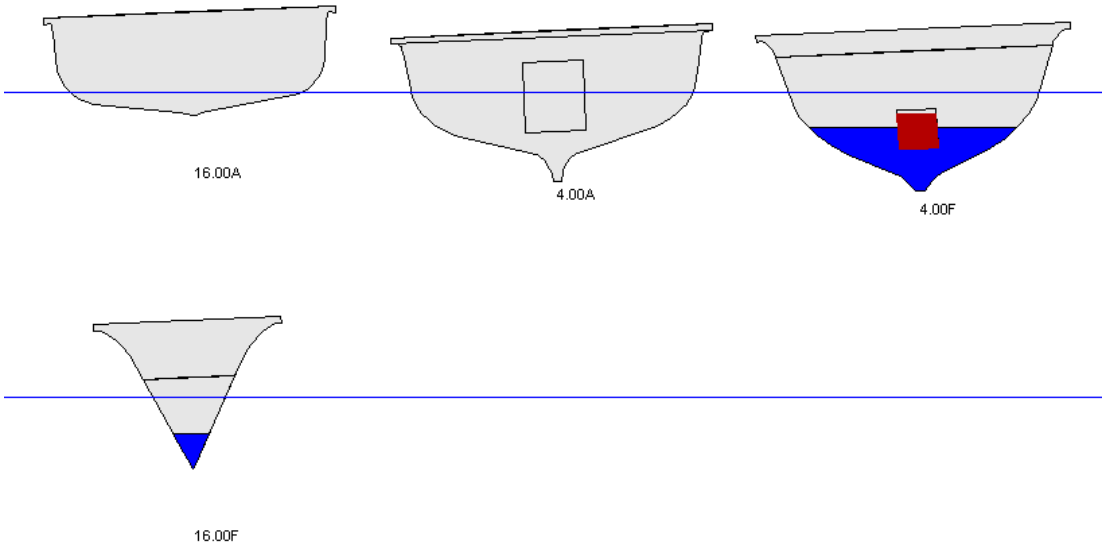
Cross Sections
1,000 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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Intact Trim and Stability Summary
1,200 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.49F	0.01P	88.3	
Misc. Tanks	10,010.0	2.01	5.72F	0.17P	38,470.9	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	33,747.5	4.75	0.63F	0.10P	38,559.2	
Stability Calculation			**Trim Calculation**			
KMt	7.04	ft	LCF Draft		3.55	ft
VCG	4.75	ft	LCB		0.80F	ft-MS
GMt (Solid)	2.29	ft	LCF		2.17A	ft-MS
FSc	1.14	ft	MT1in		1.84	ft-LT/in
GMt (Corrected)	1.15	ft	Trim		2.60	ft-F
			List		2.6P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.42	ft				
Draft at M.S.	3.71	ft				
Draft at F.P.	5.01	ft				
Draft at Aft Marks	2.37	ft				
Draft at Mid Marks	3.71	ft				
Draft at Fwd Marks	5.06	ft				

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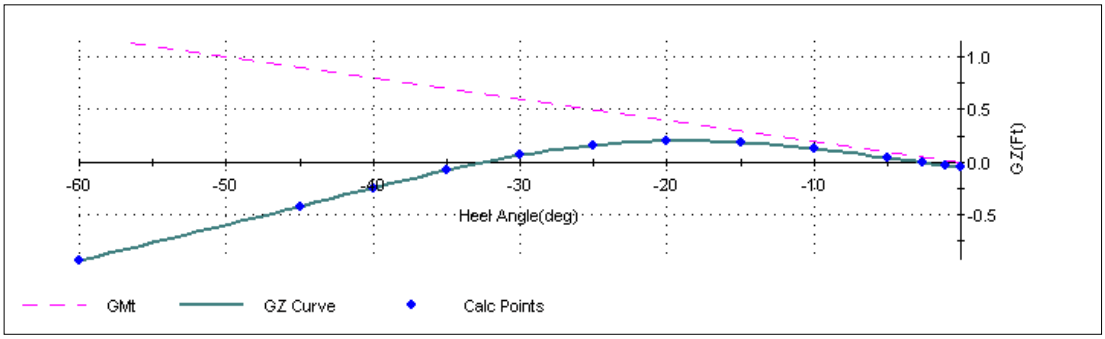
4/5/2006

Righting Arm Summary
1,200 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.6P
Angle at Maximum GZ	**deg**	19.1P
Area to 19.1 deg	**ft-deg**	2.28
Maximum GZ	**ft**	0.20
Range of Positive GZ	**deg**	29.8

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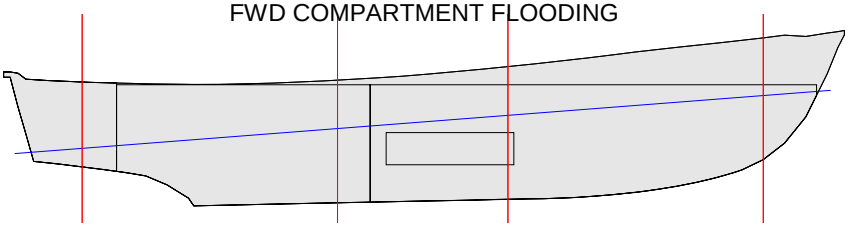
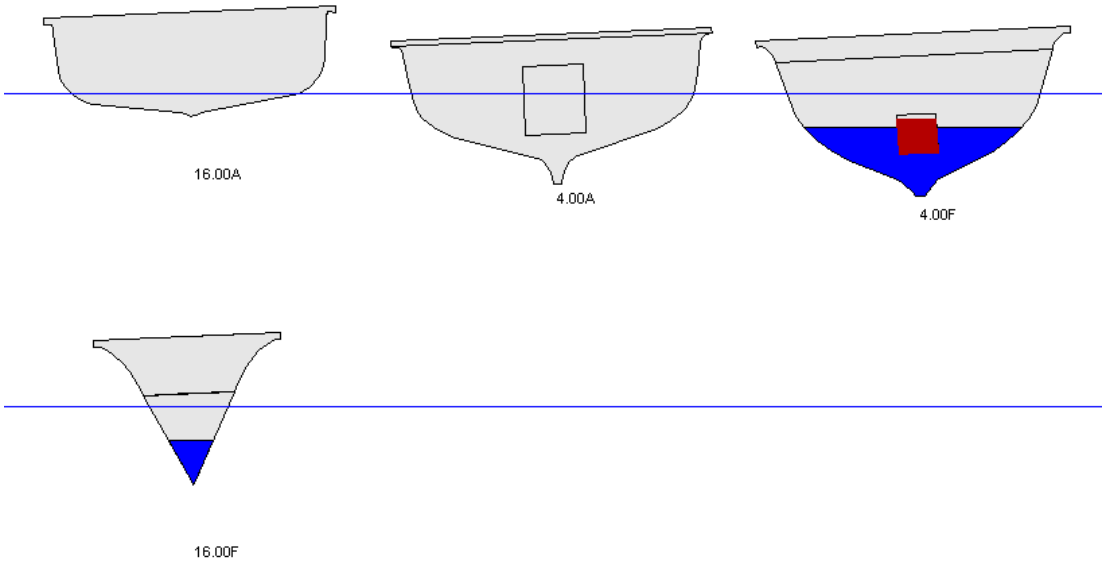
Cross Sections
1,200 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



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4/5/2006

Intact Trim and Stability Summary
1,450 gal

FWD COMPARTMENT FLOODING

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.52F	0.01P	88.3	
Misc. Tanks	12,095.4	2.19	5.89F	0.17P	44,905.6	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	35,832.9	4.66	0.99F	0.11P	44,993.9	
Stability Calculation			**Trim Calculation**			
KMt	6.94	ft	LCF Draft		3.67	ft
VCG	4.66	ft	LCB		1.16F	ft-MS
GMt (Solid)	2.29	ft	LCF		1.95A	ft-MS
FSc	1.26	ft	MT1in		1.88	ft-LT/in
GMt (Corrected)	1.03	ft	Trim		2.97	ft-F
			List		2.7P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.36	ft				
Draft at M.S.	3.84	ft				
Draft at F.P.	5.33	ft				
Draft at Aft Marks	2.30	ft				
Draft at Mid Marks	3.84	ft				
Draft at Fwd Marks	5.39	ft				

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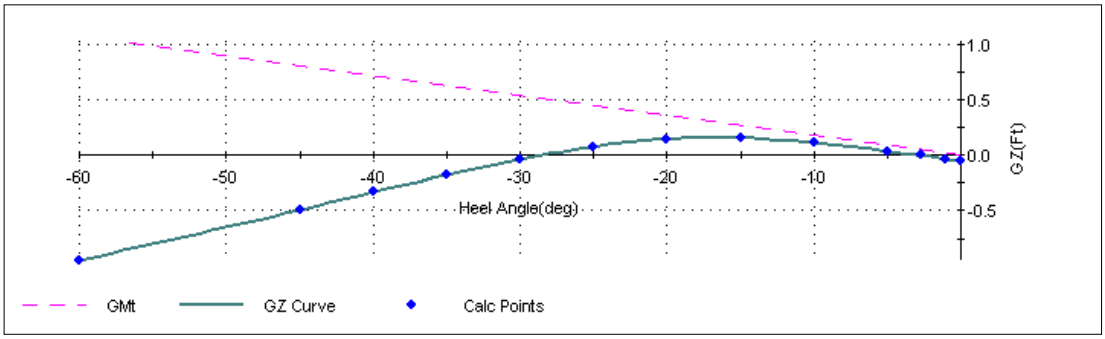
4/5/2006

Righting Arm Summary
1,450 gal

FWD COMPARTMENT FLOODING
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.7P
Angle at Maximum GZ	**deg**	16.7P
Area to 16.7 deg	**ft-deg**	1.45
Maximum GZ	**ft**	0.16
Range of Positive GZ	**deg**	26.0

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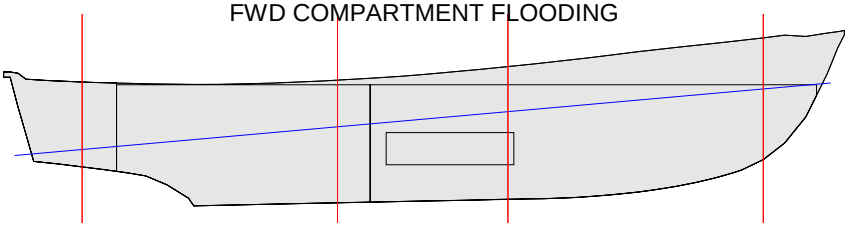
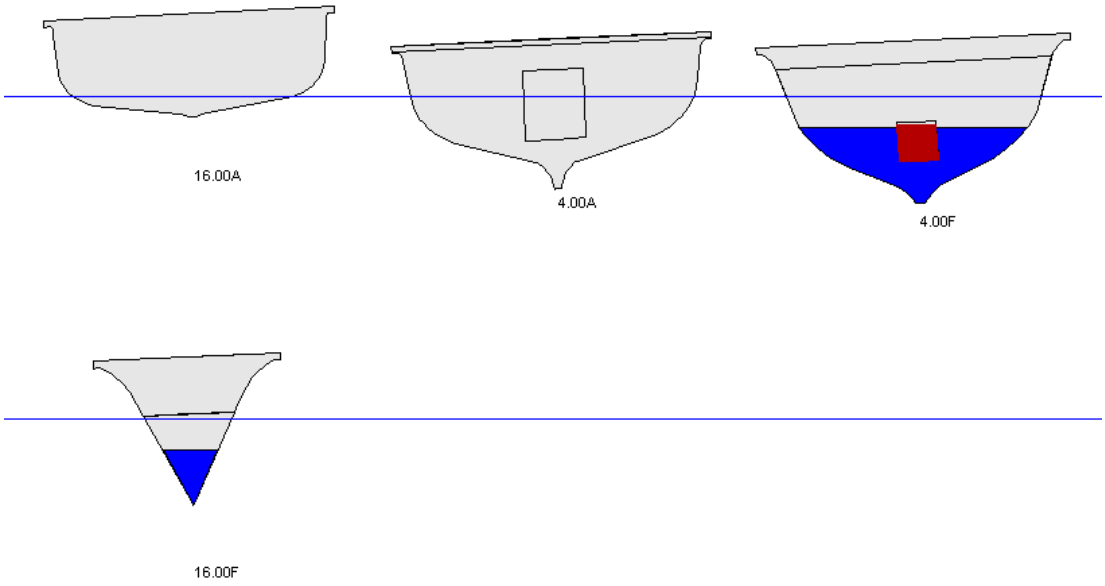
Cross Sections
1,450 gal

FWD COMPARTMENT FLOODING



Sections looking forward - units (ft-MS)



APPENDIX E

TANK TABLES

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ER

TANK TABLE - ER

		Height				Center			aterplar
No.	**Innage**	**Keel**	**Ref**	**Volume**	**Volume**	**LCG**	**VCG**	**TCG**	**FSt**
	in	**in**	**in-BL**	**gal**	**bbls**	**in-MS**	**in-BL**	**in-CL**	**ft4**
1	---	-2.7	-2.7	---	0.0	123.3A	-2.7	0.0S	---
2	3.6	0.9	0.9	3.3	0.1	82.5A	-0.3	0.0S	0
3	7.2	4.5	4.5	9.9	0.2	77.1A	1.7	0.0S	0
4	10.8	8.1	8.1	20.1	0.5	74.9A	4.1	0.0S	0
5	14.4	11.7	11.7	37.5	0.9	74.2A	6.9	0.0P	2
6	17.9	15.3	15.3	73.7	1.8	73.4A	10.2	0.0P	20
7	19.3	16.7	16.7	100.0	2.4	74.2A	11.6	0.0P	44
8	20.3	17.7	17.7	119.1	2.8	74.8A	12.6	0.0P	62
9	21.5	18.9	18.9	150.5	3.6	76.2A	13.8	0.0P	100
10	22.9	20.2	20.2	200.0	4.8	78.6A	15.1	0.0P	174
11	24.1	21.4	21.4	242.3	5.8	80.6A	16.2	0.0P	237
12	25.1	22.4	22.4	288.8	6.9	82.8A	17.2	0.0P	312
13	26.6	23.9	23.9	358.7	8.5	86.0A	18.3	0.0P	428
14	27.3	24.6	24.6	400.0	9.5	87.3A	18.9	0.0P	492
15	28.7	26.1	26.1	478.8	11.4	90.0A	20.0	0.0P	612
16	30.6	27.9	27.9	591.3	14.1	92.4A	21.3	0.0P	749
17	30.7	28.0	28.0	600.0	14.3	92.6A	21.4	0.0P	757
18	32.3	29.6	29.6	703.6	16.8	94.2A	22.5	0.0P	859
19	32.4	29.7	29.7	709.8	16.9	94.2A	22.6	0.0P	864
20	33.7	31.0	31.0	800.0	19.0	95.2A	23.5	0.0P	935
21	34.1	31.4	31.4	824.3	19.6	95.5A	23.7	0.0P	954
22	34.9	32.2	32.2	880.6	21.0	96.0A	24.2	0.0P	991
23	35.8	33.1	33.1	942.2	22.4	96.5A	24.8	0.0P	1,028
24	35.9	33.2	33.2	950.0	22.6	96.6A	24.8	0.0P	1,032
25	36.6	33.9	33.9	1,000.0	23.8	96.8A	25.3	0.0P	1,056
26	39.0	36.3	36.3	1,175.1	28.0	97.9A	26.7	0.0P	1,137
27	39.4	36.7	36.7	1,200.0	28.6	98.0A	26.9	0.0P	1,146
28	39.5	36.8	36.8	1,208.3	28.8	98.0A	27.0	0.0P	1,149
29	42.2	39.5	39.5	1,408.7	33.5	98.7A	28.6	0.0P	1,207
30	42.7	40.1	40.1	1,450.0	34.5	98.9A	28.9	0.0P	1,217
31	43.1	40.4	40.4	1,473.7	35.1	98.9A	29.1	0.0P	1,222
32	45.3	42.6	42.6	1,642.6	39.1	99.4A	30.4	0.0P	1,254
33	46.6	44.0	44.0	1,743.2	41.5	99.6A	31.1	0.0P	1,269
34	46.8	44.1	44.1	1,755.3	41.8	99.6A	31.2	0.0P	1,270
35	48.4	45.7	45.7	1,876.6	44.7	99.8A	32.1	0.0P	1,286
36	50.2	47.6	47.6	2,015.1	48.0	100.1A	33.1	0.0P	1,301
37	53.8	51.1	51.1	2,289.0	54.5	100.4A	35.0	0.0P	1,328
38	57.4	54.7	54.7	2,568.7	61.2	100.6A	37.0	0.0P	1,361
39	61.0	58.3	58.3	2,865.2	68.2	100.6A	39.0	0.0P	1,420
40	64.6	61.9	61.9	3,164.8	75.4	100.6A	41.0	0.0S	1,304
41	67.4	64.7	64.7	3,404.6	81.1	100.6A	42.6	0.0P	489
42	68.2	65.5	65.5	3,477.3	82.8	100.6A	43.1	0.0P	---
				3,477.3	82.8				1,420

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FWD

TANK TABLE - FWD

		Height				Center			aterplar
No.	**Innage**	**Keel**	**Ref**	**Volume**	**Volume**	**LCG**	**VCG**	**TCG**	**FSt**
	in	**in**	**in-BL**	**gal**	**bbls**	**in-MS**	**in-BL**	**in-CL**	**ft4**
1	---	-0.6	-0.6	---	0.0	21.6A	-0.6	0.0S	---
2	3.5	2.9	2.9	6.1	0.1	21.3F	1.8	0.0P	0
3	7.0	6.4	6.4	24.7	0.6	35.3F	4.1	0.0P	1
4	10.4	9.9	9.9	61.0	1.5	41.5F	6.6	0.0P	6
5	12.4	11.8	11.8	100.0	2.4	43.0F	8.1	0.0P	22
6	13.6	13.1	13.1	125.0	3.0	44.0F	9.1	0.0P	32
7	13.9	13.3	13.3	130.7	3.1	44.2F	9.4	0.0P	35
8	16.1	15.5	15.5	200.0	4.8	44.8F	11.0	0.0P	79
9	17.4	16.8	16.8	241.4	5.7	45.2F	12.0	0.0P	105
10	17.6	17.0	17.0	250.0	6.0	45.2F	12.2	0.0P	111
11	20.4	19.9	19.9	375.0	8.9	45.8F	14.3	0.0P	198
12	21.0	20.4	20.4	400.0	9.5	45.9F	14.7	0.0P	216
13	23.1	22.5	22.5	500.0	11.9	47.1F	16.0	0.0P	284
14	24.3	23.8	23.8	561.0	13.4	47.8F	16.8	0.0P	325
15	25.0	24.5	24.5	600.0	14.3	48.2F	17.3	0.0P	350
16	25.5	24.9	24.9	625.0	14.9	48.4F	17.6	0.0P	365
17	27.7	27.1	27.1	750.0	17.9	49.5F	19.0	0.0P	443
18	28.5	28.0	28.0	800.0	19.0	49.9F	19.5	0.0P	471
19	29.7	29.1	29.1	875.0	20.8	50.4F	20.3	0.0P	513
20	30.7	30.1	30.1	935.1	22.3	50.9F	20.9	0.0P	547
21	31.3	30.7	30.7	975.1	23.2	51.1F	21.3	0.0P	569
22	31.7	31.1	31.1	1,000.0	23.8	51.3F	21.5	0.0P	581
23	34.5	34.0	34.0	1,200.0	28.6	52.5F	23.4	0.0P	677
24	35.2	34.7	34.7	1,250.0	29.8	52.7F	23.8	0.0P	698
25	37.9	37.3	37.3	1,450.0	34.5	53.7F	25.5	0.0P	777
26	38.3	37.7	37.7	1,475.5	35.1	53.8F	25.7	0.0P	787
27	38.5	38.0	38.0	1,500.0	35.7	53.9F	25.9	0.0P	794
28	41.5	41.0	41.0	1,750.0	41.7	54.7F	27.8	0.0P	868
29	41.7	41.2	41.2	1,765.3	42.0	54.7F	28.0	0.0P	872
30	42.9	42.3	42.3	1,870.1	44.5	55.0F	28.7	0.0P	896
31	42.9	42.3	42.3	1,870.1	44.5	55.0F	28.7	0.0P	896
32	44.4	43.8	43.8	2,000.0	47.6	55.4F	29.7	0.0P	925
33	45.2	44.6	44.6	2,072.2	49.3	55.6F	30.2	0.0P	941
34	48.7	48.1	48.1	2,389.5	56.9	56.5F	32.3	0.0P	1,002
35	52.2	51.6	51.6	2,716.7	64.7	57.3F	34.4	0.0P	1,063
36	53.1	52.5	52.5	2,805.2	66.8	57.6F	35.0	0.0P	1,080
37	55.6	55.1	55.1	3,053.9	72.7	58.2F	36.5	0.0P	1,127
38	59.1	58.5	58.5	3,401.1	81.0	59.1F	38.6	0.0P	1,196
39	62.4	61.8	61.8	3,740.3	89.1	59.9F	40.6	0.0P	1,147
40	62.6	62.0	62.0	3,758.2	89.5	59.9F	40.7	0.0P	1,145
41	65.3	64.7	64.7	4,043.7	96.3	60.6F	42.3	0.0P	467
42	66.1	65.5	65.5	4,126.2	98.2	60.7F	42.7	0.0P	---
				4,126.2	98.2				1,196

APPENDIX F

PASSENGER TRANSVERSE WEIGHT SHIFT DETAIL RESULTS

JMS NA&SE
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HECSALV 7.6.6beta

Intact Trim and Stability Summary
pax wt TCG 0ft

PASSENGER WEIGHT SHIFT

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.34F	0.00	88.2	
Misc. Tanks	0.0	---	---	---	---	
Misc. Weights	8,522.0	7.21	0.36F	0.00	0.0	
Displacement	23,737.5	5.91	1.52A	0.00	88.2	
Stability Calculation			**Trim Calculation**			
KMt	7.80	ft	LCF Draft		2.97	ft
VCG	5.91	ft	LCB		1.44A	ft-MS
GMt (Solid)	1.89	ft	LCF		3.26A	ft-MS
FSc	0.00	ft	MT1in		1.60	ft-LT/in
GMt (Corrected)	1.88	ft	Trim		0.70	ft-F
			List		0.0	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.69	ft				
Draft at M.S.	3.04	ft				
Draft at F.P.	3.39	ft				
Draft at Aft Marks	2.67	ft				
Draft at Mid Marks	3.04	ft				
Draft at Fwd Marks	3.40	ft				

JMS NA&SE
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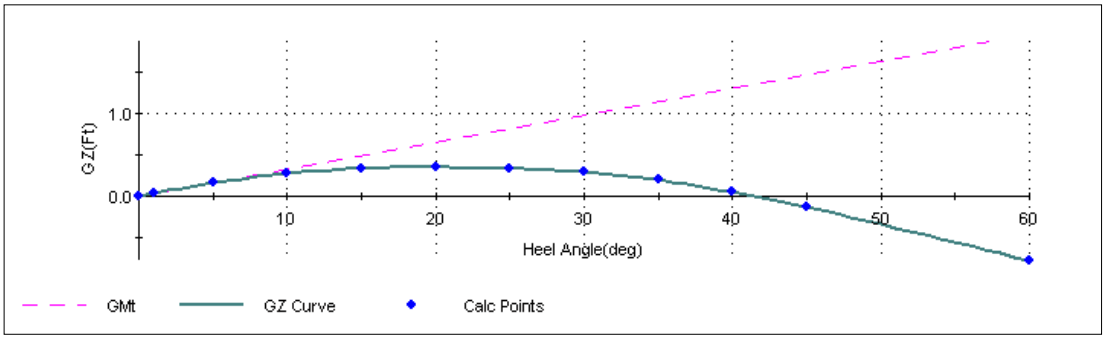
HECSALV 7.6.6beta

Righting Arm Summary
pax wt TCG 0ft

PASSENGER WEIGHT SHIFT
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	0.0
Angle at Maximum GZ	**deg**	19.2
Area to 19.2 deg	**ft-deg**	4.77
Maximum GZ	**ft**	0.35
Range of Positive GZ	**deg**	41.4

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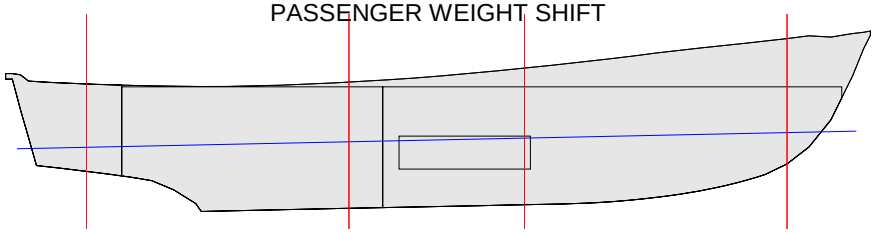
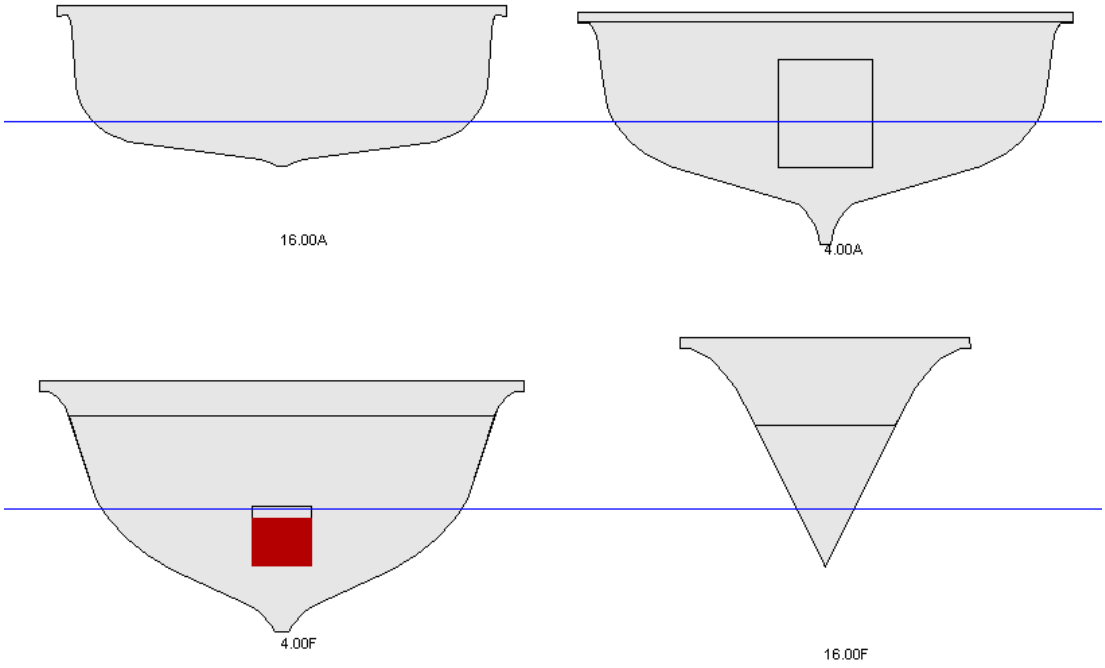
Cross Sections
pax wt TCG 0ft

PASSENGER WEIGHT SHIFT



Sections looking forward - units (ft-MS)



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HECSALV 7.6.6beta

Intact Trim and Stability Summary
pax wt TCG -0.2ft ACTUAL

PASSENGER WEIGHT SHIFT

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.34F	0.01P	88.2	
Misc. Tanks	0.0	---	---	---	---	
Misc. Weights	8,522.0	7.21	0.36F	0.20P	0.0	
Displacement	23,737.5	5.91	1.52A	0.07P	88.2	
Stability Calculation			**Trim Calculation**			
KMt	7.80	ft	LCF Draft		2.97	ft
VCG	5.91	ft	LCB		1.44A	ft-MS
GMt (Solid)	1.89	ft	LCF		3.25A	ft-MS
FSc	0.00	ft	MT1in		1.60	ft-LT/in
GMt (Corrected)	1.88	ft	Trim		0.71	ft-F
			List		2.2P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.68	ft				
Draft at M.S.	3.04	ft				
Draft at F.P.	3.39	ft				
Draft at Aft Marks	2.67	ft				
Draft at Mid Marks	3.04	ft				
Draft at Fwd Marks	3.40	ft				

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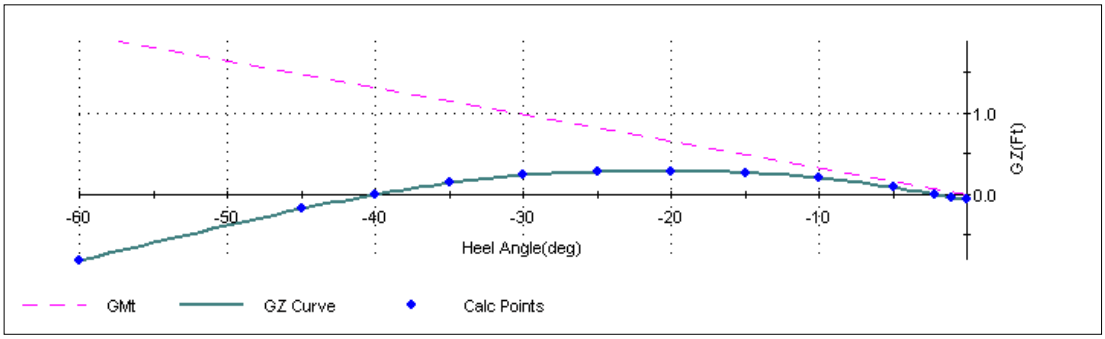
HECSALV 7.6.6beta

Righting Arm Summary
pax wt TCG -0.2ft ACTUAL

PASSENGER WEIGHT SHIFT
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	2.2P
Angle at Maximum GZ	**deg**	19.6P
Area to 19.6 deg	**ft-deg**	3.44
Maximum GZ	**ft**	0.28
Range of Positive GZ	**deg**	37.6

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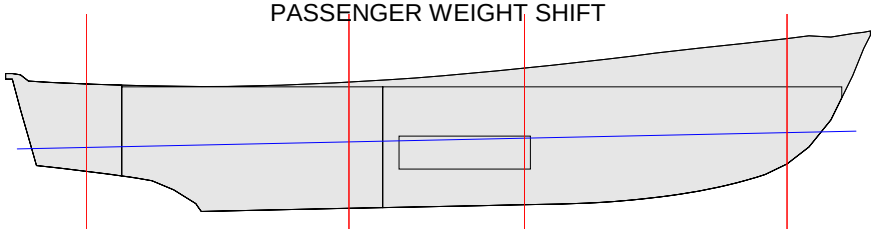
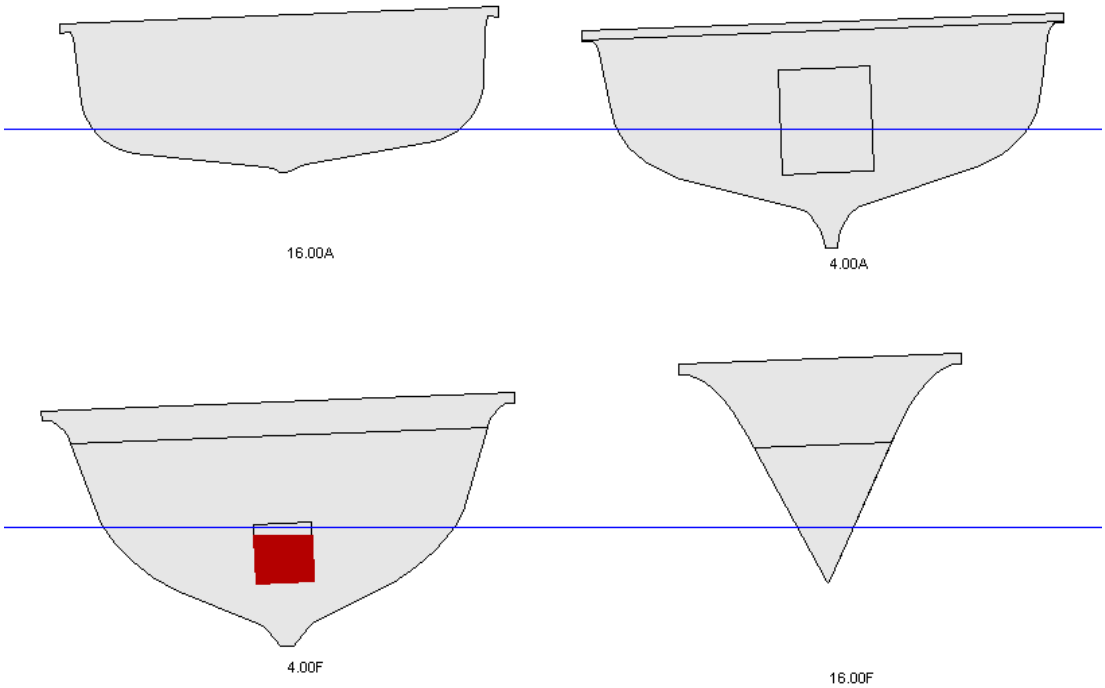
Cross Sections
pax wt TCG -0.2ft ACTUAL

PASSENGER WEIGHT SHIFT



Sections looking forward - units (ft-MS)



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HECSALV 7.6.6beta

Intact Trim and Stability Summary
pax wt TCG -0.4ft

PASSENGER WEIGHT SHIFT

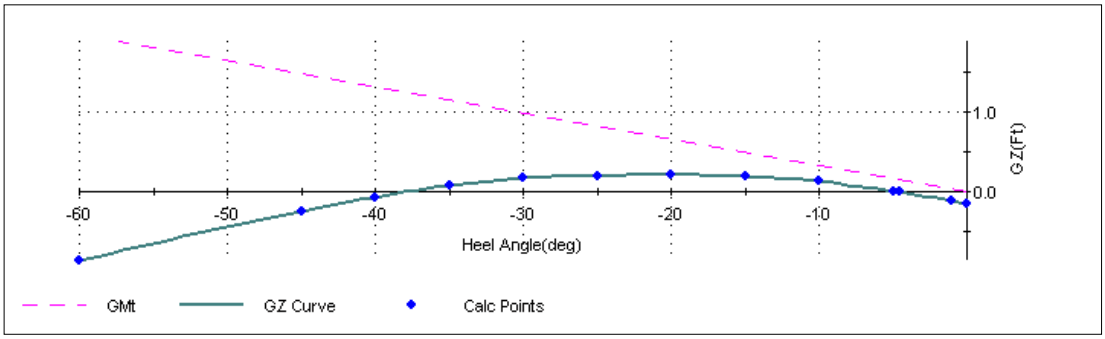
Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.34F	0.01P	88.2	
Misc. Tanks	0.0	---	---	---	---	
Misc. Weights	8,522.0	7.21	0.36F	0.40P	0.0	
Displacement	23,737.5	5.91	1.52A	0.14P	88.2	
Stability Calculation			**Trim Calculation**			
KMt	7.80	ft	LCF Draft		2.96	ft
VCG	5.91	ft	LCB		1.44A	ft-MS
GMt (Solid)	1.89	ft	LCF		3.20A	ft-MS
FSc	0.00	ft	MT1in		1.59	ft-LT/in
GMt (Corrected)	1.88	ft	Trim		0.71	ft-F
			List		4.5P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.67	ft				
Draft at M.S.	3.03	ft				
Draft at F.P.	3.39	ft				
Draft at Aft Marks	2.66	ft				
Draft at Mid Marks	3.03	ft				
Draft at Fwd Marks	3.40	ft				

JMS NA&SE
Ethan Allen

HECSALV 7.6.6beta

Righting Arm Summary
pax wt TCG -0.4ft

PASSENGER WEIGHT SHIFT
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	4.5P
Angle at Maximum GZ	**deg**	19.9P
Area to 19.9 deg	**ft-deg**	2.28
Maximum GZ	**ft**	0.21
Range of Positive GZ	**deg**	33.5

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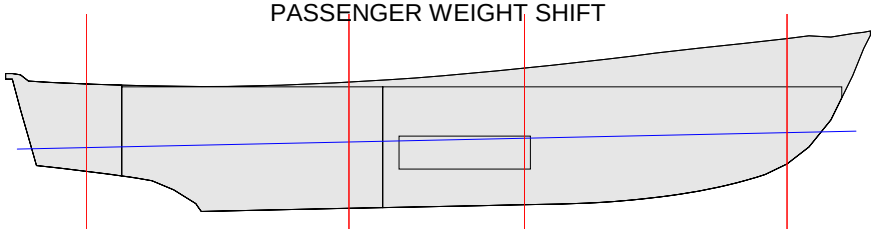
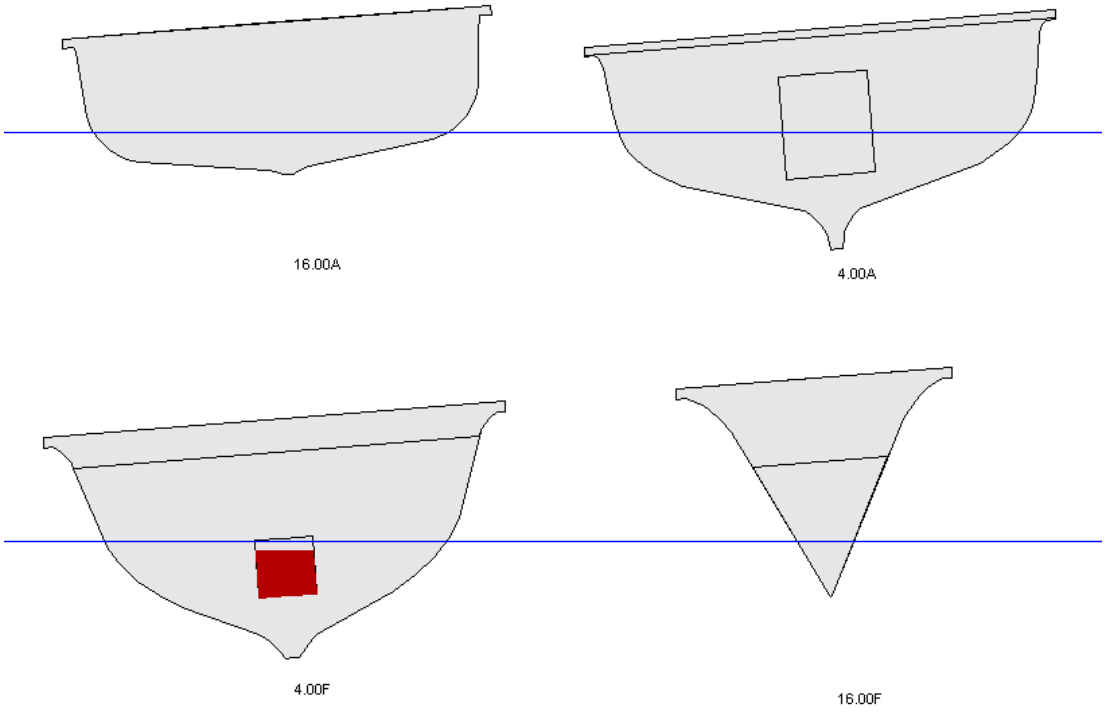
HECSALV 7.6.6beta

Cross Sections
pax wt TCG -0.4ft

PASSENGER WEIGHT SHIFT



Sections looking forward - units (ft-MS)



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HECSALV 7.6.6beta

Intact Trim and Stability Summary
pax wt TCG -0.6ft

PASSENGER WEIGHT SHIFT

Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.27	1.34F	0.02P	88.2	
Misc. Tanks	0.0	---	---	---	---	
Misc. Weights	8,522.0	7.21	0.36F	0.60P	0.0	
Displacement	23,737.5	5.91	1.52A	0.22P	88.2	
Stability Calculation			**Trim Calculation**			
KMt	7.80	ft	LCF Draft		2.95	ft
VCG	5.91	ft	LCB		1.43A	ft-MS
GMt (Solid)	1.89	ft	LCF		3.08A	ft-MS
FSc	0.00	ft	MT1in		1.56	ft-LT/in
GMt (Corrected)	1.88	ft	Trim		0.73	ft-F
			List		7.1P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.65	ft				
Draft at M.S.	3.02	ft				
Draft at F.P.	3.38	ft				
Draft at Aft Marks	2.63	ft				
Draft at Mid Marks	3.02	ft				
Draft at Fwd Marks	3.40	ft				

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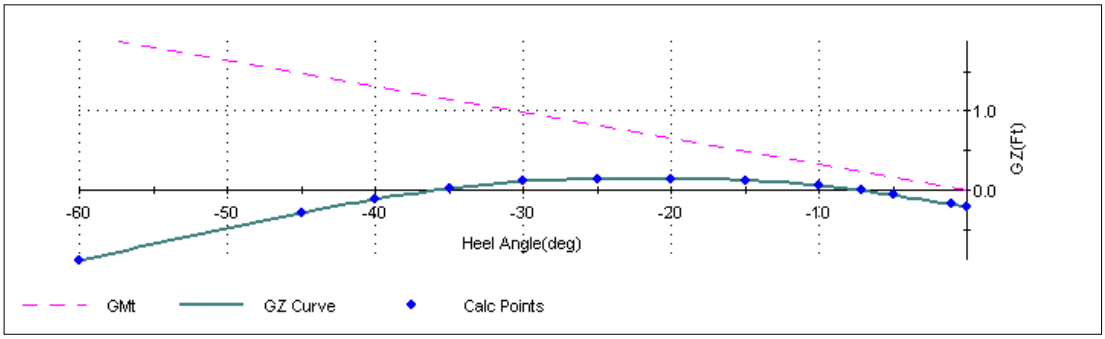
HECSALV 7.6.6beta

Righting Arm Summary
pax wt TCG -0.6ft

PASSENGER WEIGHT SHIFT
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	7.1P
Angle at Maximum GZ	**deg**	20.3P
Area to 20.3 deg	**ft-deg**	1.43
Maximum GZ	**ft**	0.15
Range of Positive GZ	**deg**	28.8

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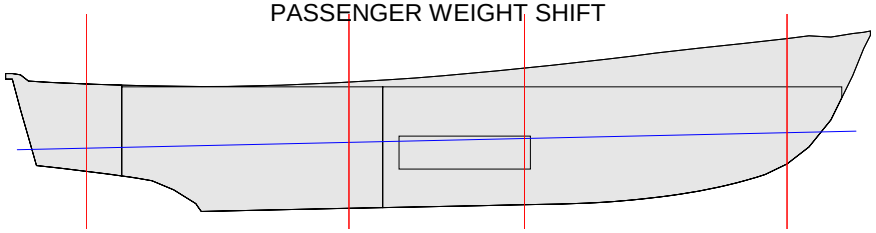
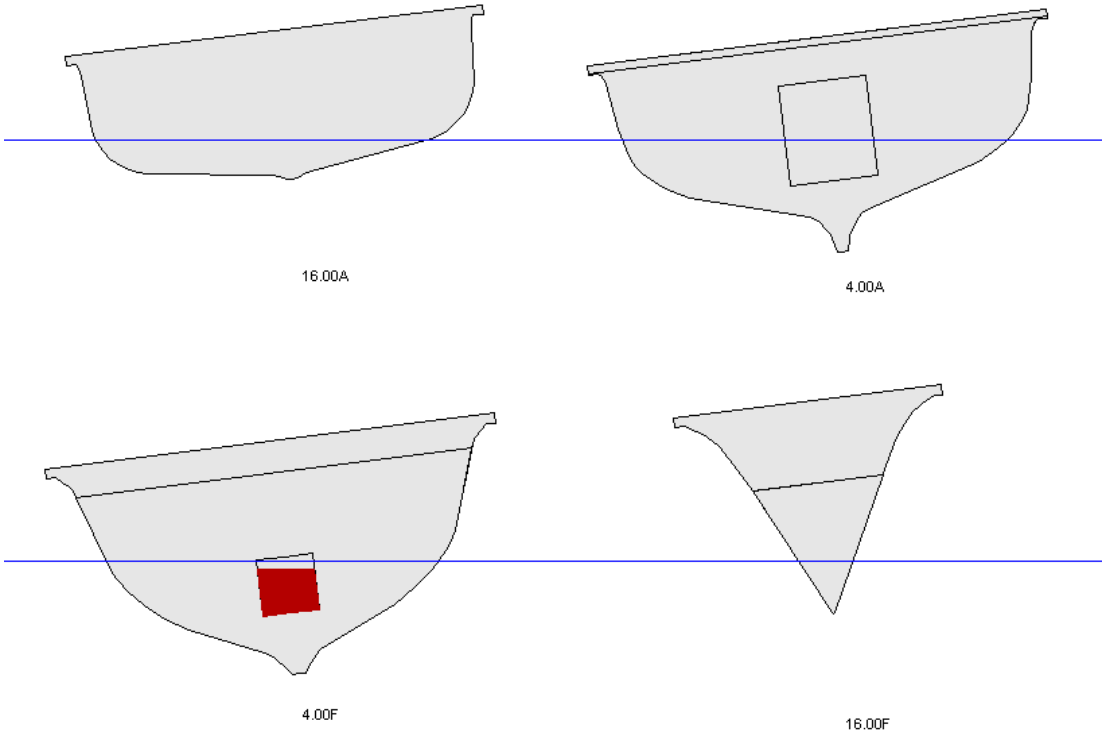
Cross Sections
pax wt TCG -0.6ft

PASSENGER WEIGHT SHIFT



Sections looking forward - units (ft-MS)



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4/5/2006

Intact Trim and Stability Summary
pax wt TCG -0.8ft

PASSENGER WEIGHT SHIFT

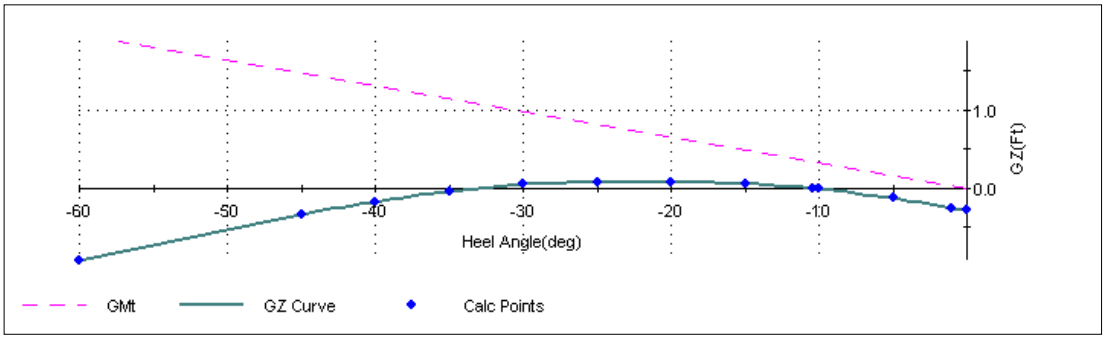
Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.35F	0.03P	88.2	
Misc. Tanks	0.0	---	---	---	---	
Misc. Weights	8,522.0	7.21	0.36F	0.80P	0.0	
Displacement	23,737.5	5.91	1.52A	0.29P	88.2	
Stability Calculation			**Trim Calculation**			
KMt	7.80	ft	LCF Draft		2.92	ft
VCG	5.91	ft	LCB		1.43A	ft-MS
GMt (Solid)	1.89	ft	LCF		2.86A	ft-MS
FSc	0.00	ft	MT1in		1.51	ft-LT/in
GMt (Corrected)	1.88	ft	Trim		0.77	ft-F
			List		10.5P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.60	ft				
Draft at M.S.	2.99	ft				
Draft at F.P.	3.37	ft				
Draft at Aft Marks	2.59	ft				
Draft at Mid Marks	2.99	ft				
Draft at Fwd Marks	3.39	ft				

JMS NA&SE
Ethan Allen

HECSALV 7.6.6beta
4/5/2006

Righting Arm Summary
pax wt TCG -0.8ft

PASSENGER WEIGHT SHIFT
No Criteria



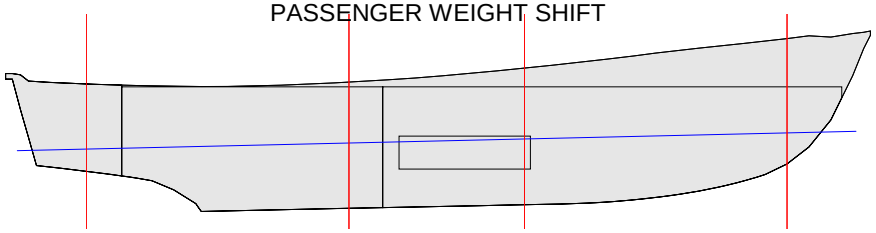
Parameter	Units	Available
Angle of Heel	**deg**	10.5P
Angle at Maximum GZ	**deg**	20.7P
Area to 20.7 deg	**ft-deg**	0.58
Maximum GZ	**ft**	0.08
Range of Positive GZ	**deg**	22.7

JMS NA&SE
Ethan Allen

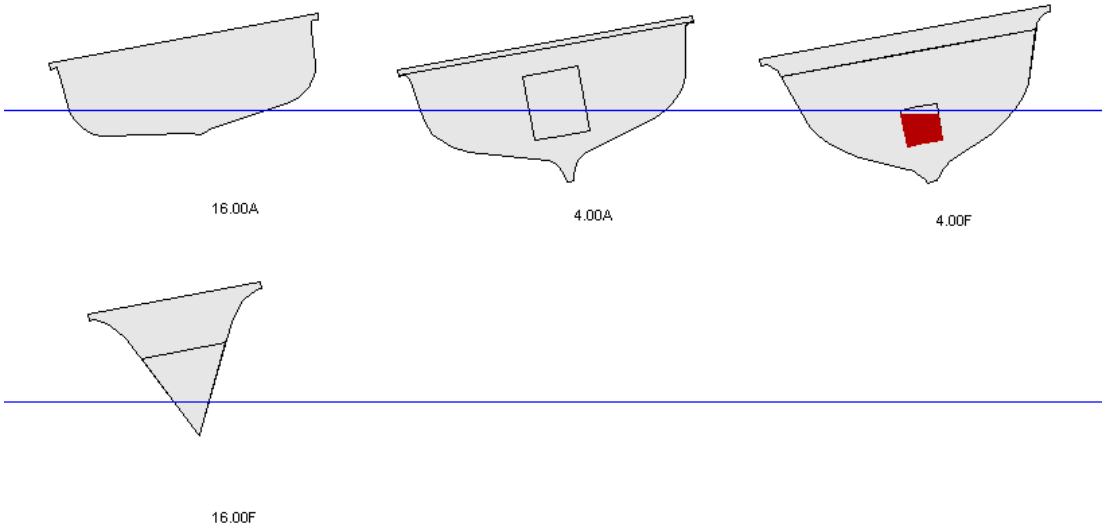
HECSALV 7.6.6beta
4/5/2006

Cross Sections
pax wt TCG -0.8ft

PASSENGER WEIGHT SHIFT



Sections looking forward - units (ft-MS)



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HECSALV 7.6.6beta

Intact Trim and Stability Summary
pax wt TCG -1.0ft

PASSENGER WEIGHT SHIFT

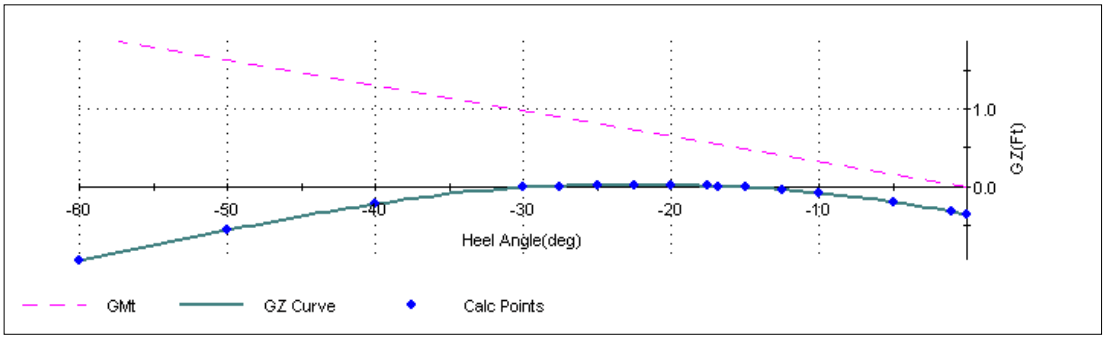
Item	Weight lbs	VCG ft	LCG ft-MS	TCG ft-CL	FSMom ft-lbs	
Light Ship	14,689.0	5.29	2.71A	0.00	---	
Constant	0.0	0.00	0.00	0.00	0.0	
Fuel Oil	526.5	2.28	1.36F	0.05P	88.2	
Misc. Tanks	0.0	---	---	---	---	
Misc. Weights	8,522.0	7.21	0.36F	1.00P	0.0	
Displacement	23,737.5	5.91	1.52A	0.36P	88.2	
Stability Calculation			**Trim Calculation**			
KMt	7.80	ft	LCF Draft		2.83	ft
VCG	5.91	ft	LCB		1.42A	ft-MS
GMt (Solid)	1.89	ft	LCF		2.44A	ft-MS
FSc	0.00	ft	MT1in		1.45	ft-LT/in
GMt (Corrected)	1.88	ft	Trim		0.92	ft-F
			List		16.8P	deg
Specific Gravity	1.0					
Hull calcs from offsets			Tank calcs from offsets			
GM from GZ curve slope						
Drafts						
Draft at A.P.	2.44	ft				
Draft at M.S.	2.90	ft				
Draft at F.P.	3.36	ft				
Draft at Aft Marks	2.42	ft				
Draft at Mid Marks	2.90	ft				
Draft at Fwd Marks	3.37	ft				

JMS NA&SE
Ethan Allen

HECSALV 7.6.6beta

Righting Arm Summary
pax wt TCG -1.0ft

PASSENGER WEIGHT SHIFT
No Criteria



Parameter	Units	Available
Angle of Heel	**deg**	16.8P
Angle at Maximum GZ	**deg**	21.4P
Area to 21.4 deg	**ft-deg**	0.04
Maximum GZ	**ft**	0.01
Range of Positive GZ	**deg**	11.1

JMS NA&SE
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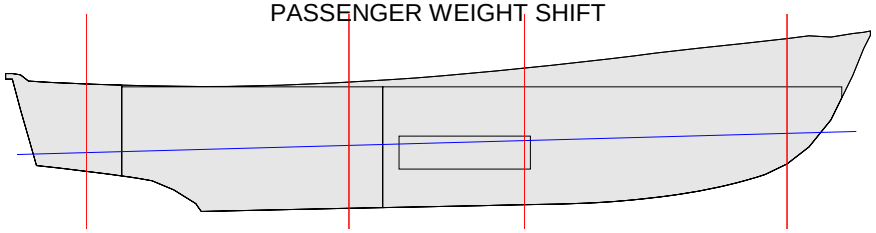
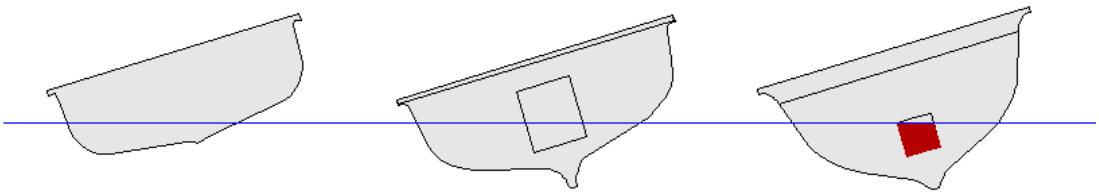
Cross Sections
pax wt TCG -1.0ft

PASSENGER WEIGHT SHIFT



Sections looking forward - units (ft-MS)